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Comparison of Juvenile Steelhead Densities, 1997 through 2001, In the San Lorenzo River and Tributaries, Santa Cruz County, California; With an Estimate of Juvenile Population Size and an Index of Adult Returns

Prepared by

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***For the Following Agencies*;**

City of Santa Cruz Water Department,

San Lorenzo Valley Water District,

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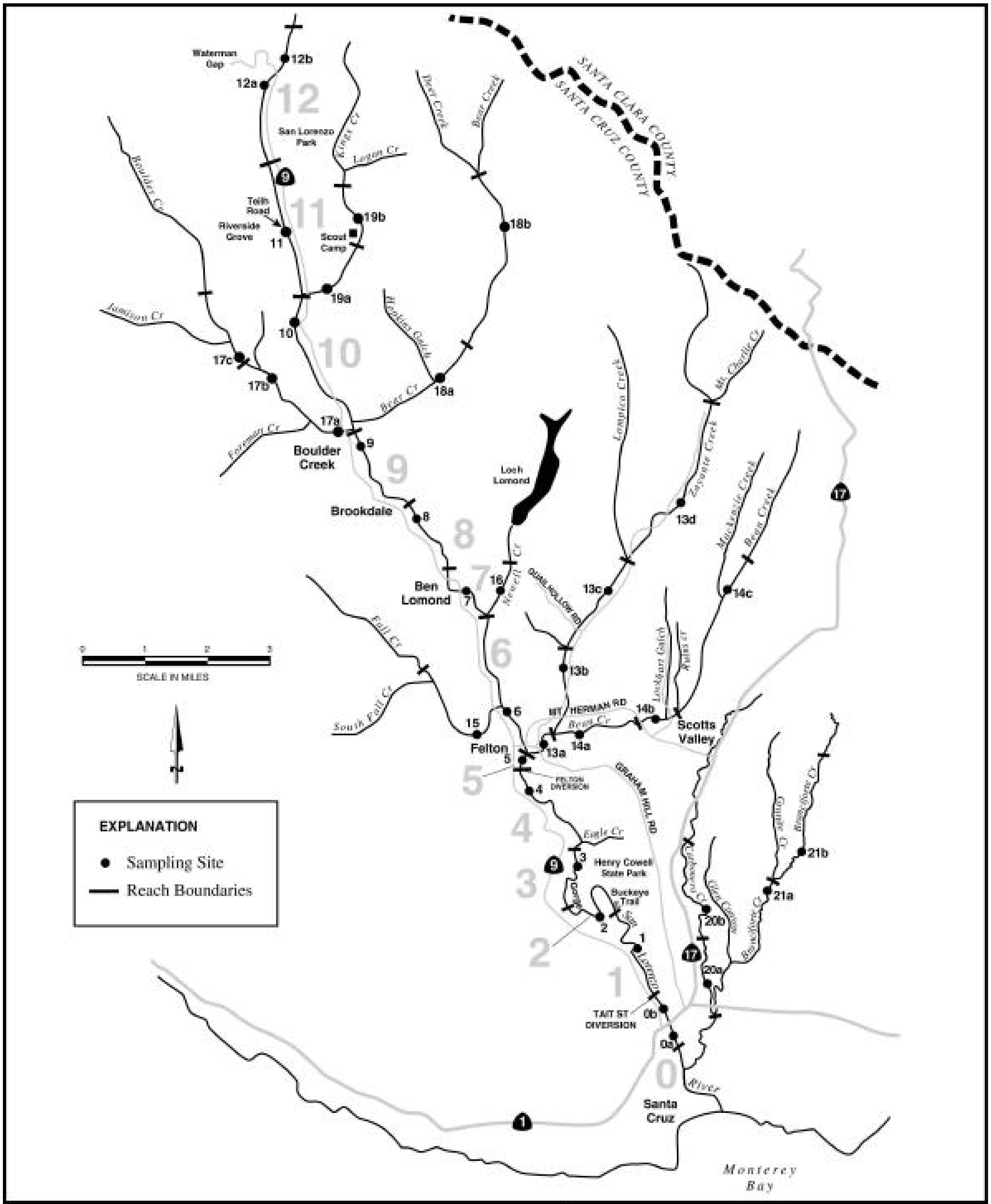
Approach to Estimating Juvenile Steelhead Population Size

For management purposes, we have needed to know if habitat quality is improving or not and where. We have needed to know where most of the fish are produced, both YOY's and smolt-sized fish, or which reaches have the highest potential, before we may direct management efforts. We have needed to know how the juvenile population is responding to habitat changes. The juvenile production estimates for reaches that have resulted from our sampling of average quality habitat, in our judgment, has provided adequate accuracy to detect trends in annual steelhead production and changes in size classes and age classes in relation to changes in habitat conditions (increased smolt-sized juveniles when escape cover and water depth increase). This sampling regime has allowed comparisons in juvenile production and habitat quality between reaches within tributaries and in the mainstem, between tributaries themselves, and between the 9 major tributaries and the mainstem. Their relative contribution to an index of steelhead adults was also forthcoming. The sampling regime and production estimates have been adequate to detect El Niño impacts from high mortality to overwintering fish, sedimentation and poor oceanic conditions. The sampling regime has detected changes in juvenile growth rate in response to differences in annual baseflow. We have detected improved YOY survival in years when stormflows occurred primarily early in the winter.

Juvenile steelhead were sampled and habitat was evaluated in the San Lorenzo River drainage to compare 2001 fish densities with those in 1996 through 2000 in this major steelhead-producing system flowing into the northern Monterey Bay (**Next page and Appendix A; Figure 2**). The intent was also to detect coho salmon juveniles, which was unsuccessful. In the mainstem, juvenile steelhead densities and numbers of fish were estimated in 12 reaches (25 channel miles) from densities at 14 mainstem sites factored in with habitat proportions determined by habitat-typing (**Tables 1a and 1c**). In addition, juvenile densities and numbers of fish were also determined in the 9 major tributaries (33 channel miles) by sampling of 20 tributary sites in habitat-typed reaches (**Appendix A; Figure 2; Tables 1b and 1c**).

Statistical Analysis of Juvenile Densities at Sampling Sites

Differences in densities of juvenile size classes and age classes between 2000 and 2001 were statistically analyzed. Both Size Class 1 and Age Class 1 increased over the whole basin (**Table 43a**) by more than 8 fish per 100 feet. This difference was highly significant statistically. Both Size Class 2 and Age Class 2 decreased by slightly over 1 fish per 100 feet. But the difference was not statistically significant due to the variation and the small difference. The results were essentially the same both in significance and magnitude for the two subdivisions of the basin (**Tables 43b and 43b**), for lower mainstem sites and separately for the upper mainstem with tributary sites.



APPENDIX A, FIGURE 2 Reach & Site Designations in the San Lorenzo River Drainage
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Mainstem Juvenile Numbers and Habitat Changes

Overall Trend. As a whole, mainstem production of YOY's had steadily declined from 1997 to 2000 with 81,300, 52,500, 34,300 and 18,200, respectively (**Table 54**). The decline in 2000 was likely related to reduced adult returns after the El Niño period. However, mainstem YOY production rebounded in 2001 to 30,600, despite lower streamflow than in 2000. A statistically significant increase in YOY densities was found at sampling sites in 2001. Yearling numbers continued to decline for 1997-2001 with 8,400, 5,500, 7,300, 5,600 and 4,800, respectively. No statistical difference was found for yearling densities at sampling sites between 2000 and 2001. As a result of yearling densities and YOY's that grew into the larger size class, the 1997-2001 estimates for larger, smolt-sized juveniles produced in the mainstem continued to decline with 24,800, 26,600, 24,100 and 12,500 and 11,700, respectively (**Table 55**). Only the lower River produced more smolt-sized fish in 2001, this being due to more YOY's growing into Size Class 2. In 2001, there were fewer yearlings, and YOY's grew more slowly with reduced streamflow than past years. Closer evaluation of the three sub-units of the mainstem (lower, middle and upper) indicated that 2001 YOY production was much improved in all three, although it remained less than 1999 production in the lower and middle River. YOY production has not yet returned to 1997 and 1998 levels. The production of larger juveniles was at a 5-year low for the middle River and remained low in the lower and upper River as occurred in 2000.

Lower River. YOY numbers were similar in the lower River in 1998 (15,700) and 1999 (15,000), but totaled only 4,900 in 2000 and 9,100 in 2001. The 2001 Y-O-Y production was about 60% of the 1998 and 1999 estimates. Yearling production in the lower River in 2001 (1,000) was similar to 2000 (1,200) and 1998 (1,100) but only about half of 1999 production (2,100). Numbers of larger juveniles in the => 75 mm SL range were similar in 1997 (14,400), 1998 (14,700) and 1999 (15,900) in the lower River, indicating that the carrying capacity for the valuable larger juveniles remained in the 14,000-16,000 range over the three years. But numbers plummeted in 2000 (4,500) and remained low in 2001 (6,400).

Estimated Number of Juvenile Steelhead by Age-Class in the San Lorenzo River Mainstem from Highway 1 to Above Waterman Gap in the Fall of 1996-2001, with 1998-2001 Tributary Estimates Included.

YEAR	# OF YOUNG-OF-THE-YEAR STEELHEAD	# OF YEARLING STEELHEAD	TOTAL NUMBER OF JUVENILES
1996 Mainstem	62,000*	9,500*	71,500*
1997 Mainstem	81,500	8,500	89,500
1998 Mainstem	52,500	5,500	58,000
1999 Mainstem	34,500	7,500	41,500
2000 Mainstem	18,000	5,500	24,000
2001 Mainstem	30,500	5,000	35,500
1998 Tribs.	103,500	9,500	113,000
1999 Tribs.	74,500	28,000	102,500
2000 Tribs.	61,000	17,500	78,500
2001 Tribs.	69,500	17,000	86,500
1998 TOTAL	156,000	15,000	171,000
1999 TOTAL	109,000	35,000	144,000
2000 TOTAL	79,500	23,000	102,500
2001 TOTAL	100,000	22,000	122,000

* Estimates were rounded to the nearest 500. Estimates for all juveniles differed when combining age classes versus size classes because density estimates at sampling sites were determined separately by age and size.

Estimated Number of Juvenile Steelhead by SIZE-CLASS in the San Lorenzo River Mainstem From Highway 1 to Above Waterman Gap in Fall of 1981, 1994-2001, with Tributary Estimates Included in 1998-2001.

YEAR	# OF SIZE-CLASS 1 STEELHEAD (< 75 mm SL)	# OF SIZE-CLASSES 2 & 3 STEELHEAD (=> 75 mm SL)	TOTAL NUMBER OF JUVENILES
1981 Mainstem	37,000*	31,500	69,000
1994 Mainstem	24,500	23,000	45,000
1995 Mainstem	37,000	38,000	75,000
1996 Mainstem	40,000	32,500	72,500
1997 Mainstem	63,000	25,000	88,000
1998 Mainstem	31,000	26,000	58,000
1999 Mainstem	17,500	24,000	41,500
2000 Mainstem	12,500	11,000	23,500
2001 Maintsem	23,500	11,500	35,000
1998 Tribs.	91,500	19,000	111,000
1999 Tribs.	73,500	28,500	102,000
2000 Tribs.	59,000	19,500	78,500
2001 Tribs.	70,000	16,500	86,500
1998 TOTAL	123,000	45,500	168,500
1999 TOTAL	91,000	53,000	144,000
2000 TOTAL	72,000	30,500	102,500
2001 TOTAL	93,500	28,000	121,500

Estimates are approximate and rounded to the nearest 500.

Positive and Negative Habitat Changes from 2000 to 2001 at Sampling Sites in the San Lorenzo River Mainstem. (Refer to footnotes for symbol explanation.)

	Lower River					Middle River				Upper River		
Habitat Parameter	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8	R-9	R-10	R-11	R-12
Riffle Escape Cover	+++	+++		+++	+++	+++	+++	+++	+++	---	---	+++
Run Escape Cover	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	---
Pool Escape Cover	+++									+++	+++	+++
Mean Riffle Depth	---	---	---	---	---	---	---	---	---	---	---	+++
Mean Run/Step-run Depth		---	+++	---	+++		---	---	---	+++		---
% Sand-Riffles	---	---	---	---	+++							
% Sand-Stp-rn/ run		---		---		---	+++			+++	---	
Embeddedness- Riffle/runs	+++		+++	+++	+++	+++	+++	+++		+++	+++	+++

+++ denotes habitat condition improved.
--- denotes habitat condition worsened.
Blank space denotes similar or same values except for Pool Escape Cover, for which no data were collected in 2001.

There were fewer yearlings in both 2000 and 2001 compared to 1999. In 2001, growth rate was reduced with a smaller proportion of YOY's reaching larger size. In 1998 with high baseflow and likely the greatest spawning success later in the winter and spring, 13,600 YOY's (87%) reached Size Class 2. In 1999-2001 there were 13,300 (89%), 3,900 (80%) and 5,100 (56%), respectively, that reached Size Class 2.

Rearing habitat quality in 2001 improved overall in the lower River fastwater habitat with regard to reduced embeddedness and more escape cover (due to more overhanging vegetation) except for cover in riffles in the Gorge where whitewater was reduced. However, some aspects of habitat quality declined. There was reduced streamflow, which reduced habitat depth and insect drift rate. Percent fines also increased in 2001. The fall baseflow in the lower River in 2001 was 10-30% less than in 2000 and the lowest since 1994, with the greatest decline in the upper portions (**Table 19**). Baseflow declined to 20 cfs at the Big Trees Gage by early July in 2001, but not until early October in 2000.

Egg survival in 2001 was probably higher than in 2000 because there were no bankfull events and only one near 1800 cfs in 2001, occurring in late February (**Figure 42**). Bankfull discharge is typically considered to reoccur every 1.5 years (recurrence interval). Bankfull discharge is the minimum flow thought to have channel-forming capabilities, and may be the approximate flow when spawning beds begin to wash away or become smothered with sediment. On the San Lorenzo River the flood flow of 2,800 cfs had a 1.3 recurrence interval, may be within the range of the estimated bankfull event.

In 2000 there were at least 3 bankfull events occurring in January and February (**Figure 41**). In 2000, the large stormflows came later than in the three previous years, with 6 peak flows greater than 1,800 cfs occurring in middle to late February. Another late storm came in middle April 2000, which may have moved sediment, buried some redds and/or scoured others. Despite the more favorable conditions in 2001 with less potential for redd scour than in earlier years, YOY production in the lower River had not fully recovered to the 1997-1999 levels.

Middle River. The middle River had shown continued annual decline in Y-O-Y production in 1997-2000 with 33,000, 31,100, 12,600 and 3,200, respectively (**Table 54**). However it rebounded somewhat in 2001 back up to 10,000. It was still down from pre-El Niño effects. The numbers of yearlings produced in 1997-2001 showed a continued decline with 3,600, 2,100, 1,800, 700 and 500, respectively. Numbers of smolt-sized juveniles in 1997-2001 showed a progressive decline with 7,000, 8,500, 4,300, 2,100 and 1,400, respectively (**Table 55**).

Fewer yearlings in 2001 may have resulted from the considerable reduction in Y-O-Y's in 2000 compared to earlier years. As in the lower River, the same habitat conditions improved at fastwater sampling sites, including reduced embeddedness and more escape cover. Percent fines were similar to 2000. However, water depth and insect drift declined due to reduced streamflow. Baseflow declined 20-30% at sites in the middle River in 2001 compared to 2000 (**Table 19**). Growth rate of YOY's was reduced with reduced streamflow. A positive correlation has been developed between streamflow and the percent of YOY's reaching Size Class 2 (**Alley et al. Draft Report 2002**). The relationship was developed from fish densities at sampling sites and streamflow estimates of the years, 1981 and 1994-97. In 2001 there were 700 YOY's (7%) that reached Size Class 2. In 2000 there were 1,400 (44%) that reached Size Class 2. There had been much less competition in 2000 with fewer fish, which promoted growth. In 1999 there were 2,400 YOY's (19%) that reached Size Class 2.

Upper River. The upper River above the Boulder Creek confluence in 2001 was still recovering from the onslaught of sediment entering the mainstem in 1998. Estimated YOY production in 1997 through 2001 was 25,800, 5,800, 6,800, 10,000 and 11,500, respectively (**Table 54**). Adult access to Waterman Gap may still have been restricted by the illegal log dam, road riprap in the River and the Highway 9 culvert crossing and concrete apron that were observed in 2000. The estimated number of yearlings in the upper River in 1997-2001 was 3,400, 2,200, 3,400, 3,800 and 3,300, respectively. Production of larger juveniles (=> 75 mm SL) in 1997-2001 was 3,400, 3,500, 3,900, 4,500 and 3,900 respectively. Surprisingly, more YOY's grew into Size Class 2 in 2001 than 2000 despite the reduced streamflow. In 2001 there were 1,200 YOY's (10%) that reached Size Class 2. In 2000, 400 (4%) reached Size Class 2. Fall baseflow had declined at least 50% in 2001 in the upper River (**Table 19**). The higher growth rate was observed in Reaches 10 and 11, with slower growth rate in Reach 12, where yearling density had increased to a 5-year high. The unexpected higher growth rate may have resulted from earlier spawning success in 2001, leading to a longer growth period before fall sampling. Also, yearling density was much reduced in Reaches 10 and 11, offering less competition for

YOY's and possibly allowing faster growth.

Habitat in the upper River continued to improve slightly in 2001 as it had in 2000. As in the lower and middle River, embeddedness was similar or slightly less in 2001. Escape cover was improved in pools and run/step-run habitat. Percent fines were reduced in pools in Reach 11 and run/step-runs in Reaches 10 and 12. Percent fines were similar in riffles in the upper River and increased in pools of Reach 12. Habitat depth declined at all sites except at Site 12a in the canyon below Waterman Gap where scour apparently had occurred.

Juvenile Numbers and Habitat Conditions in Tributaries

Overall Trends. In general, YOY production was increased in tributaries in 2001, as was the case in the mainstem. However, unlike the mainstem, tributaries had similar numbers of yearlings in both years. Perhaps yearlings that might have migrated into the mainstem from the tributaries in years with higher stormflows remained in the tributaries during the mild winter of 2000-2001. Although streamflow declined in most tributaries and growth rate declined, escape cover increased in pools at many sites due to increased overhanging vegetation, as was the case in the mainstem.

Young-of-the-Year and Size Class 1. The relative differences in reach densities for YOY fish in 2001 and 2000 were the same as for Size Class 1 densities (**Table 61**). Fifteen of 20 reaches showed increased YOY and Size Class 1 densities in 2001. Reach densities increased in all reaches of Zayante, Fall, Newell, Boulder Bear creeks (**Table 60**). Kings Creek was similar in 2000 and 2001, but slightly lower in 2001. Bean Creek's upper reach was lower in 2001 but not directly comparable to 2000 because some of it was dry in 2001, and the sites were different between years. Streamflow resurfaced a short distance above the 2000 site in upper Bean Creek. Carbonera and Branciforte creeks had one reach each with lower density in 2001 and one with higher. But the overall stream density was slightly higher in 2001.

Production estimates for YOY juveniles in 2001 indicated increases in 7 of 9 tributaries compared to 2000, especially in Zayante and Bear creeks (**Table 54; Figure 19**). The 2001 tributary production estimate was 30,200 compared to 22,200 in 2000. However, it was slightly less than the 31,900 estimated for 1999 and was far less than the 103,600 estimated in 1998.

Yearlings and Larger Size Classes. Comparisons of reach densities of yearlings between 2000 and 2001 in tributaries paralleled those of larger juvenile size classes (**Table 61**). Looking at tributary production of yearlings, those that noticeably increased in 2001 were Bean, Fall and Kings creeks (**Table 53; Figure 20**). Branciforte and Carbonera creeks had sizeable declines. Other tributaries had similar yearling densities between years. The number of yearlings produced in the tributaries was similar in 2001 (17,100) as in 2000 (17,300) (**Table 54 and 57**).

Densities of fish =>75 mm SL declined at 13 of 20 sites in 2001 (**Table 57**). Reach densities of yearlings and Size Classes 2 and 3 fish declined in most reaches of the Zayante-Bean and Branciforte-

Carbonera sub-basins, along with Newell, lower Boulder and lower Bear (**Table 60**). Large increases in reach densities of larger juveniles occurred in middle Boulder, upper Bear and upper Kings creeks. Other reaches were similar between the two years. Zayante and Bear creeks had notably fewer Size Class 2 and 3 juveniles in 2001 due to slower growth rate, and Branciforte had fewer, as well (**Table 55**). The number of larger juveniles produced in tributaries was less in 2001 (16,300 compared to 19,500 in 2000) (**Table 55 and 56**). This was likely because there were fewer YOY from 2000 to be recruited as yearlings, growth rate was reduced due to reduced streamflow and perhaps there was reduced rearing habitat for larger juveniles in some tributaries with less streamflow than in 2000.

Overall Juvenile production. In 2001, overall density of juveniles declined slightly for the Zayante (including Bean) and Branciforte (including Carbonera) sub-basins compared to 2000, largely due to reduced yearling densities (**Table 59**). Total densities in other tributaries increased in 2001, largely due to increased YOY production. Tributary production of juveniles increased notably in 2001 in Zayante, Boulder and Bear creeks with more YOY's (**Table 55; Figure 21**). Estimated total numbers declined most in Bean Creek in 2001, though differences between years were somewhat vague because portions of upper Bean Creek went dry in 2001 that were watered in 2000. The overall juvenile production in 2001 was greater than in 2000, but less than 1998 and 1999 (**Table 56**).

Branciforte Creek. Habitat quality at sampling sites in Branciforte Creek did not change in any consistent manner in 2001 with regard to non-streamflow related factors. Mean pool depth increased at both sites, which was unusual in tributaries in 2001, but maximum depth decreased slightly. In the lower site, fastwater habitat decreased in embeddedness while pools increased. The opposite was true for embeddedness at the upper site. Escape cover increased in pools at the upper site and declined at the lower site. Escape cover was probably the most important habitat parameter, indicating improved habitat in the upper site and habitat loss at the lower site. However, only YOY density improved at the lower site. Percent fines decreased at the lower site in pools and runs. Undoubtedly, streamflow declined in 2001, though no measurements were taken. The reduction in yearling density at both sites indicated reduced rearing habitat quality.

Carbonera Creek. Habitat conditions generally worsened in Carbonera Creek in 2001. The positive change was more escape cover and reduced percent fines in pools of the upper site. Habitat depth declined at both sites and escape cover in pools of the lower site worsened. Percent fines increased in runs/step-runs of both sites but lessened in lower site riffles slightly. Undoubtedly, streamflow declined in 2001, though no measurements were taken. The reduction in yearling density at both sites indicated reduced rearing habitat quality.

Habitat Changes from 2000 to 2001 in Tributary Sites of the San Lorenzo River. (Refer to footnotes for symbol explanations.

Habitat Parameter	Branciforte	Carbonera	Zayante	Bean*	Fall	Newell	Boulder	Bear	Kings
Pool Escape cover	- +	- +	+	+	+	+	+	+ -	+
Max. Pool Depth	-	-	+ - + -	+	-	-	- - +	-	-
Mean Pool Depth	+	-	+ - + -	+	-	-	s - +	-	- +
Run/Stp-rn Mean Depth	-	s -	s - - -	- + +	+	+	-	- +	-
% Sand-Pools	-	s +	-	+ + s	+	+	s	+ -	-
% Sand-Riffles	s +	- s	s + + +	- + -	-	+	+ - +	-	+
% Sand-Stp-rn/ run	+ s	-	- - s s	- s -	-	+	- - +	- -	s -
Embeddedness- Riffle/Runs	+ -	-	-	- - +	+	+	- - +	- +	s -
Embeddedness- Pools	- +	+ s	- + - -	+ s +	-	-	- + +	+ -	+ -

+ Denotes improvement in habitat condition.

- Denotes worsening in habitat condition.

- + Denotes worsening in the lower reach and improvement in the upper reach. Zayante Creek had 4 reaches. Bean and Boulder creeks had 3 reaches.

S Denotes same or similar habitat conditions in both 2000 and 2001.

*** Upper Bean Creek Site had to be moved because the 2000 site was dry.**

Zayante Creek. In Zayante Creek, a general improvement in habitat quality was observed related to escape cover. It increased in pools at all 4 sites. Fallen trees existed at the second and third sites (13b-c). Mean and maximum pool depth increased at the lower and third site upstream, despite the reduced streamflow. Pool depth declined significantly at only Site 13b. Degraded factors included similar or higher embeddedness fastwater and pool habitat. Percent fines were similar or increased in fastwater habitat at all sites. However, percent fines increased in pool habitat at all sites. Fall baseflow was reduced 10% at Site13a and by 1/3 at Site 13b above Bean Creek confluence (**Table 19**). These reduced streamflows were responsible for reduced growth rate in YOY's in 2001. In 2000 there were 1,400 YOY's that grew into Size Class 2, whereas only about 100 YOY's did so in 2001 (**Tables 54 and 55**).

Bean Creek. Habitat quality in Bean Creek generally improved at sites in 2001. Escape cover and depth were increased in pools at all three sites, despite the reduced streamflow. Embeddedness in pools declined at the lower and upper sites as did embeddedness in fastwater habitat at the upper site. Improved embeddedness at the upper site was probably due its location being further upstream. Percent fines increased in riffle and run habitat of the lower and upper sites and was similar in other habitats. Measured streamflow at Site 14b was slightly higher in 2001 than 2000 (**Table 19**).

Fall Creek. The juvenile population in Fall Creek increased with improvement of some aspects of habitat quality in 2001. Improvements included more pool escape cover in the form of woody debris, greater depth in run/step-run habitat and reduced fastwater habitat embeddedness. Most habitat was fastwater in Fall Creek. Pool depth declined and pool embeddedness increased, although percent fines in pools declined. Despite less embeddedness, percent sand increased in fastwater habitat. Fall baseflow was the same in both 2000 and 2001 (**Table 19**).

Newell Creek. Habitat conditions that improved in Newell Creek in 2001 included reduced percent fines in riffles, runs and pools, more escape cover in pools due to more overhanging vegetation and reduced embeddedness in fastwater habitat. Conditions that worsened were reduced pool depth and more pool embeddedness. The continued low yearling numbers despite habitat improvement was unclear. The reduced pool depth implied that streamflow was less in 2001, though it was not measured. It had been measured at 0.5 cfs in 2000 (**Table 19**).

Boulder Creek. Habitat quality mostly improved in the upper Site 17 of Boulder Creek and mostly declined at the lower two sites in 2001, although pool escape cover improved at all 3 sites. In the uppermost site, the following parameters improved; more pool escape cover, greater pool depth, less sand in fastwater habitat (similar in pools) and reduced embeddedness in fastwater habitat and pools. The sediment apparently moved down into the middle reach where pool and fastwater habitat depth decreased and sand and embeddedness increased in fastwater habitat. However, pool substrate at Site 17b improved with lower embeddedness, more escape cover and much higher densities of yearlings. The lower site had more escape cover in pools and less sand in riffles. However, maximum depth declined, depth in run/step-run habitat declined, percent sand and embeddedness increased in step-run habitat and embeddedness increased in pool habitat while percent sand was similar. The cause of substantial decline in yearlings at the lower site was unclear.

Bear Creek. Habitat conditions mostly deteriorated in Bear Creek in 2001 after improvement the two previous years. Water depth declined in all habitats at both sites except in step-run habitat at the upper site. Percent fines and embeddedness increased in all habitats except pools at the lower site, and embeddedness greatly improved in step-runs at the upper site. Pool escape cover increased slightly at the lower site, but only YOY densities dramatically increased. Yearlings decreased at the lower site. Yearling densities improved at the upper site where escape cover decreased in pools in 2001.

Kings Creek. There was the first indication of habitat improvement in upper Kings Creek since the El Niño winter of 1997-98 that brought considerable sedimentation. There was more escape cover there with higher mean pool depth, despite the reduced streamflow in 2001. There was also less sand in riffles at both sites. However, other factors continued to worsen or were unchanged, such as reduced mean pool depth at the lower site and reduced maximum pool depth at both sites. Percent fines were similar or increased in all habitat types except riffles. Embeddedness increased in pools and step-runs at the upper site.

Approach to Obtaining an Index of Adult Returns Expected from Juvenile Production

The predicted index of returning adults from juvenile numbers was determined for mainstem and tributary reaches. This index indicated the trend in adult steelhead populations resulting from natural smolt production. The index was based on a model developed for differential survival rate of juvenile age/size classes returning as adults to Waddell Creek during the period of 1933-42 (**Shapovalov and Taft 1954**). Steelhead survival rate to spawning adults increased exponentially with increasing size of steelhead smolts (**J. Smith, personal comm.)**. The model emphasized the increased survival rate expected for larger size classes of juvenile steelhead. Dettman (**Kelley and Dettman 1987**) developed the model based on the Waddell Creek relationship between average size of each age class as smolts and survival to returning adult.

The model required estimated juvenile steelhead population numbers by size class in the fall of the year. The size classes were divided according to year-class sizes typically found in Waddell Creek, based on Smith's experience. Young-of-the-year fish were up to 75 mm Standard Length. Yearlings were from 75 mm to 150 mm Standard Length. Steelhead were considered two-year-olds if larger than 150 mm Standard Length.

To obtain a more realistic estimate of returning adults from juveniles, the estimates of returning adults derived from the Dettman model were reduced by 50%, based on the only recent estimate of returning adult steelhead to Waddell Creek in 1991-92 (**Smith 1992**).

Mainstem and Tributary Contributions to the Adult Steelhead Index

The index of adult returns expected from mainstem juveniles declined throughout the period, 1995-2000, with a slight increase in 2001 (**Figure 22**). The mainstem increase resulted from the higher number of YOY’s that grew into Size Class 2 in 2001 and occurred despite the fewer yearlings present. A smaller proportion of YOY’s reached smolt size in 2001 than 2000, but there were many more YOY’s in 2001 in the lower River, where YOY growth rate allowed some to grow to smolt size the first year. Despite the rebound in YOY’s in the tributaries, the fewer larger juveniles resulted in a lower tributary index of adults in 2001, the lowest in the 4 years of measurement. **Tables 61 and 62 and Figure 22a-b** summarize the indices of adult spawners expected from the mainstem juveniles produced in 1981 and 1994-2001, as well as indices of adult spawners from tributary juveniles produced in 1998-2001. **Indices from mainstem juveniles for 1998-2001 were 1,300, 1,150, 560 and 610 adults, respectively, representing a 9% increase from 2000 to 2001.**

The proportion of adults expected to contribute to the adult run of the watershed from mainstem juvenile production in 1998-2001 was 52%, 43%, 35% and 38%, respectively, indicating a slight increase in mainstem contribution mainly due to increased YOY production there. Dividing the contribution to the mainstem adult index into lower, middle and upper River, juvenile production from the **lower River** in 1998-2001 represented 50%, 62%, 41% and 50% of the mainstem adult index and 26%, 27%, 14% and 19% of the total watershed adult index, respectively. Juvenile production from the **middle River** in 1998-2001 represented 36%, 20%, 18% and 16% of the mainstem adult index and 19%, 9%, 6% and 6% of the watershed adult index, respectively. Juvenile production from the **upper River** in 1998-2001 would represent 14%, 18%, 41% and 34% of the mainstem adult index and 7%, 8%, 14% and 13% of the total watershed adult index, respectively.

Adult indices from tributary juveniles from 1998-2001 were 1,200, 1,500, 1,070 and 980, respectively, representing a 9% decline in 2001 (Figure 22a). The decline came mostly from the Branciforte sub-watershed where yearling production was down without a substantial increase in YOY production. In looking at the relative contributions of each tributary to the adult index, Zayante-Bean continued to be the most important sub-watershed, followed by the Branciforte-Carbonera sub-watershed, Bear and Boulder creeks. The percent of the adult index expected from juveniles produced in the various tributaries in 1998-2001 were as follows; Zayante sub-basin contributing 15%, 23%, 25% and 23.5%, Branciforte sub-basin contributing 13%, 10%, 16% and 12.5%, Bear Creek contributing 6.5%, 11%, 12% and 10%, Boulder Creek contributing 6%, 6%, 6% and 7%, Fall, Newell and Kings, combined, contributing 8%, 8%, 7% and 8% (**Table 62; Figure 22b**).

Conclusions

As a whole, mainstem production of YOY's increased in 2001 after a 4-year decline. The annual mainstem estimates were 81,300, 52,500, 34,300, 18,000 and 30,600, respectively, for 1997-2001 (**Table 53**). Mainstem yearling numbers continued to decline for 1997-2001 with 8,400, 5,500, 7,300, 5,600 and 4,800, respectively. As a result of number of yearlings and relative low growth rates of YOY's in 2001 compared to the three previous years with higher streamflow, the 1997-2001 estimates for larger, smolt-sized juveniles produced in the mainstem were 24,800, 26,600, 24,100, 11,100 and 11,700, respectively (**Table 55**). Thus, production of smolt-sized juveniles in the mainstem continued to remain relatively low compared to previous years. The 2001 increase in mainstem YOY's came from better production in the lower and middle River. The 2001 decrease in mainstem yearlings occurred throughout.

We suspect that the increased mainstem YOY production in 2001 partially resulted from higher spawning success in winter 2000-2001 than the two previous years due to milder stormflows with less substrate-moving storm events that could either scour or bury nests in sediment (**Figure 42**). There were likely more adults returning during winter of 2000-2001 than the winter before, which was supplied with adults from juveniles being negatively impacted by El Niño storms and poor oceanic conditions (**Alley 2001**). The trapping data at the Felton Diversion Dam indicated more adults returning in 2001. In addition, smolt planting in spring of 1999 by the Monterey Bay Salmon and Trout

Project had resumed to pre-El Niño levels in 1999, contributing adults to the 2000-2001 winter run. The smolt planting numbers for spring, 1995-2001 were 42,300, 28,800, 32,000, 2,200, **30,600**, 20, 400 and 22,600 respectively.

Some habitat conditions were improved in the mainstem in 2001, such as increased escape cover from more overhanging riparian trees and less substrate embeddedness. However, baseflow was reduced, which resulted in less fastwater habitat, reduced insect drift rate and slower growth rate of YOY's into the larger Size Class 2. Fastwater habitat heavily used by juveniles in the lower and middle River was shallower and percent fines increased (except in Reach 5 below the Zayante Creek confluence) to reduce its quality for insect production and fish habitat. Whitewater cover was reduced in the Gorge. The uppermost Reach 12 in Waterman Gap broke with the trend by producing more yearlings and less YOY's in 2001 compared to 2000 (**Table 48**). However, this relatively high quality habitat did not suffer the reduction in YOY densities in 2000 that other sites had (**Table 47**).

Increase in YOY numbers in 7 of 9 tributaries and reduced yearlings in 5 of 9 tributaries can be attributed partially to likely increased spawners in 2000-2001 than in 1999-2000, with associated fewer YOY's from 2000 being recruited as yearlings in 2001. There was also likely higher spawning success and YOY survival with the milder winter. The exceptions where yearling densities increased in 2001 (Bean, Fall, Boulder and Kings creeks) resulted from habitat improvement regarding more escape cover and/or increased depth in pools. In general, habitat conditions related to substrate and habitat depth deteriorated in tributaries with reduced streamflow in most (except Fall and middle Bean). Embeddedness and percent fines generally increased in tributaries. However, pool escape cover generally increased due to overhanging vegetation and fallen trees resulting from the winter snowstorm. Even though most habitat indicators declined in Fall Creek except escape cover in fastwater habitat and streamflow, YOY's and yearlings increased somewhat. Bean Creek showed the greatest habitat improvement with consistent increased escape cover and depth in pools, resulting in higher yearling production than 2000. Upper Kings Creek showed the first habitat improvements (more escape cover in pools and deeper pools) since the El Nino stormflows of 1998, and yearling densities were improved. Some of the smallest YOY's and yearlings in recent years were captured in 2001 tributaries, particularly in the uppermost sites of each. This was consistent with the reduced growth rate of YOY's in the lower and middle mainstem River. The three tributaries that showed significant overall increased juvenile production (all sizes combined) in 2001 were Zayante, Boulder and Bear creeks mainly due to more YOY's. Six of 9 tributaries showed at least a slight increase.

The index of adult returns expected from mainstem juveniles declined throughout the period, 1995-2000, with a slight increase in 2001 (**Figure 22**). This increase resulted from the higher number of YOY's that grew into Size Class 2 in 2001, leading to more smolt-sized juveniles in the lower River despite fewer yearlings present. A smaller proportion of YOY's reached smolt size in 2001 than 2000, but there were many more YOY's in 2001 in the lower River, where YOY growth rate allowed some to grow to smolt size the first year. **Tables 62 and 63 and Figure 22** summarize the indices of adult spawners expected from the mainstem juveniles produced in 1981 and 1994-2001, as well as indices of adult spawners from tributary juveniles produced in 1998-2001. **Indices from mainstem juveniles for 1998-2001 were 1,280, 1,150, 560 and 610 adults, respectively, representing a**

9% increase from 2000 to 2001.

Despite the rebound in YOY's in the tributaries, the fewer larger juveniles resulted in a lower tributary index of adults in 2001, the lowest in the 4 years of measurement. **Adult indices from tributary juveniles from 1998-2001 were 1,180, 1,520, 1,070 and 980, respectively, representing a 9% decline.** The decline came mostly from the Branciforte sub-watershed where yearling production was down without a substantial increase in YOY production. In looking at the relative contributions of each tributary to the adult index, Zayante-Bean continued to be the most important sub-watershed, followed by the Branciforte-Carbonera sub-watershed, Bear and Boulder creeks. **Adult indices from mainstem and tributary juveniles combined for 1998-2001 were 2,470, 2,670, 1,634 and 1,580 adults, respectively, representing a slight decline from 2000 to 2001.**

Estimated Adult Index of Steelhead Returns to the San Lorenzo River in 1981and 1994-2001, Including Nine Tributaries in 1998-2001, Using Dettman's Waddell Creek Model (Kelley and Dettman 1987).

SAMPLE YEAR	NUMBER OF FIRST TIME SPAWNERS	TOTAL NUMBER OF RETURNING ADULTS
1981 Mainstem	1,250	1,500
1994 Mainstem	900	1,100
1995 Mainstem	1,500	1,800
1996 Mainstem	1,300	1,500
1997 Mainstem	1,100	1,300
1998 Mainstem	1,100	1,300
1999 Mainstem	950	1,150
2000 Mainstem	450	550
2001 Mainstem	500	610
1998 Tribs.	1,000	1,200
1999 Tribs.	1,300	1,500
2000 Tribs.	900	1,100
2001 Tribs.	800	1,000
1998 Mainstem + Tribs.	2,100	2,500
1999 Mainstem + Tribs.	2,250	2,650
2000 Mainstem + Tribs.	1,350	1,650
2001 Mainstem + Tribs.	1,300	1,600

* Assumes 20% repeat spawners. Estimates Include a 50% Reduction Factor Applied to

Modeling Results, Based on Smith's 1991-92 Estimate of Adult Returns on Waddell Creek.

In 2001 the estimated adult return was 2,043 based on 538 adults trapped in 38 days at Felton. Using the percentage of hatchery origin adults to wild adults captured at the trap (26%) as an estimate of the ratio in the overall adult estimate, an estimate of 1,511 adults were wild adults from natural production. This 1,511 adult estimate was less than the adult index of 2,460 that was generated from juvenile population estimates from 1998 juveniles and the Dettman (1987) model. However, the two estimates are not markedly different, considering that spawning adults are often seen in the River in May after the primary spawning period that the estimate based on trapping is intended to represent. Also, some adults missed the trap during high stormflows when they jumped over the dam. It is important to note that the modeling index does not account for the contribution of hatchery smolts to adult returns.

If coho salmon spawned in the San Lorenzo River system in the winters of 1998 through 2001, they were too few in number to produce juveniles at detectable levels with our 35-site sampling regime.

INTRODUCTION

Regulatory Context

Both coho salmon (*Oncorhynchus kisutch*) and steelhead (*Oncorhynchus mykiss*) inhabiting the San Lorenzo River have become protected as Threatened species under the Endangered Species Act (ESA). The Threatened listing means that coho salmon and steelhead in the ESU will likely become endangered in the foreseeable future without improved conditions. Additionally, coho salmon have been listed by the State of California as an Endangered species, south of San Francisco Bay. The San Lorenzo coho salmon population (remnant) is included in one of two federal Evolutionarily Significant Units (ESUs) in California under the ESA, it being the Central California Coast ESU. This coho salmon ESU extends from Punta Gorda in the north to the San Lorenzo River in the south. The San Lorenzo steelhead population is included in one of four ESUs with Threatened status, it being in the Central California Coast ESU. The ESU for steelhead populations includes streams from the Russian River in the north to (but not including) the Pajaro River in the south.

As part of the ESA, critical habitat is designated for Threatened species, defining areas in which federally permitted projects will require Section 7 consultation with the National Marine Fisheries Service to determine conditions of the permit. A Habitat Conservation Plan (HCP) may eventually be required for the San Lorenzo River watershed to allow incidental take of coho salmon and steelhead. Independent water districts, cities (because of their public works and water supply activities), and Santa Cruz County will likely be required to join in this process. A recovery plan is being developed by the State to restore the coho salmon population so that it may be de-listed. A similar plan may be developed for steelhead. The present fish monitoring effort is supported by the City of Santa Cruz, Santa Cruz County and the San Lorenzo Valley Water District to obtain scientific information regarding the existing status of coho salmon and steelhead populations and habitat conditions. These data will be used to set population goals for de-listing and to guide habitat restoration.

Steelhead and Coho Salmon Ecology

Migration. Adult steelhead in small coastal streams tend to migrate upstream from the ocean after several prolonged storms; the migration seldom begins earlier than December and may extend into May if late spring storms develop. Many of the earliest migrants tend to be smaller than those entering the stream later in the season. Adult fish may be blocked in their upstream migration by barriers such as bedrock falls, wide and shallow riffles and occasionally log-jams. Man-made objects, such as culverts, bridge abutments and dams are often significant barriers. Some barriers may completely block upstream migration, but many barriers in coastal streams are passable at higher streamflows. If the barrier is not absolute, some adult steelhead are usually able to pass in most years, since they can time their upstream movements to match peak flow conditions. In 1992 we located a partial migrational barrier in the San Lorenzo River Gorge caused by a large boulder field, which is probably passable at flows above 100-125 cubic feet per second. In most years it is not a problem. However, in drought years and years when storms are delayed in coming, it can be a serious barrier to steelhead and particularly coho (silver) salmon spawning migration. In 1998 and 1999, a difficult passage riffle was observed in the upper portion of Reach 2 in the Rincon area. A split channel was developing, causing difficult passage conditions for adults at flows less than 60-70 cfs.

Coho salmon often have severe migrational problems because their migration period, November through February, is often prior to the peak flows needed to pass shallow riffles, boulder falls and partial logjam barriers. Access at the river mouth is also a greater problem for coho salmon because they die at maturity and cannot wait in the ocean an extra year if access is poor due to failure of sandbar breaching during drought or delayed stormflow.

Smolts (young steelhead and coho salmon which have physiologically transformed in preparation for ocean life) in local coastal streams tend to migrate downstream to the lagoon and ocean in March through June. In streams with lagoons, young- of-the-year fish may spend several months in this highly productive lagoon habitat and grow rapidly. In some small coastal streams, downstream migration can occasionally be blocked or restricted by low flows due primarily to heavy streambed percolation or early season stream diversions. Flashboard dams or closure of the stream mouth or lagoon by sandbars are additional factors, which adversely affect downstream migration. However, for most local streams, downstream migration is not a major problem except under extreme drought conditions.

Spawning. Steelhead and coho salmon require spawning sites with gravels (from 1/4" to 3 1/2" diameter) having a minimum of fine material (sand and silt) and with good flows of clean water moving over and through them. Increases in fine materials from sedimentation, or cementing of the gravels with fine materials, restrict water and oxygen flow through the redd (nest) to the fertilized eggs. These restrictions reduce hatching success. In many local streams, steelhead appear to successfully utilize substrates for spawning with high percentages of coarse sand, which probably reduce hatching success. Steelhead that spawn earlier in the winter than others, are much more likely to have their redds washed out or buried by winter storms. Steelhead spawning success may be limited by scour from winter storms in some Santa Cruz County streams. Unless hatching success has been severely reduced, however, survival of eggs and larvae is usually sufficient to saturate the limited available rearing habitat in most small coastal streams and San Lorenzo tributaries. However, in the mainstem San Lorenzo River downstream of the Boulder Creek confluence, spawning success may be an important limiting factor. The production of young-of-the-year fish is related to spawning success, which is a function of the quality of spawning conditions and ease of spawning access to upper reaches of tributaries, where spawning conditions are generally better.

Rearing Habitat. In the mainstem San Lorenzo River, downstream of the Boulder Creek confluence, many steelhead require only one summer of residence before reaching smolt size. Except in streams with high summer flow volumes (greater than 0.2 to 0.4 cubic feet per second (cfs) per foot of stream width), steelhead require two summers of residence before reaching smolt size. This is the case for most juveniles inhabiting tributaries of the San Lorenzo River. Juvenile steelhead are generally identified as young-of-the-year (first year) and yearlings (second year). The slow growth and often two-year residence time of most local juvenile steelhead indicate that the year class can be adversely affected by low streamflows or other problems during either of the two years of residence. Coho salmon, however, smolt after one year despite their small size.

Growth of young-of-the-year steelhead and coho salmon appears to be regulated by available insect food, although cover (hiding areas, provided by undercut banks, large rocks which are not buried or "embedded" in finer substrate, surface turbulence, etc.) and pool, run and riffle depth are also important in regulating juvenile numbers, especially for larger fish. During summer in the mainstem San Lorenzo River downstream of the Boulder Creek confluence, steelhead use primarily fast-water habitat where insect drift is the greatest. This habitat is found in deeper riffles, heads of pools and faster runs. Pool habitat and step-run habitat are the primary habitat for steelhead in summer in San Lorenzo tributaries and the upper San Lorenzo River above the Boulder Creek confluence because riffles and runs are very shallow, offering limited escape cover. Primary feeding habitat is at the heads of pools and in deeper pocket water of step-runs. The deeper the pools, the more value they have. Higher streamflow enhances food availability, surface turbulence and habitat depth, all factors in increasing steelhead densities and growth rates. Where they occur together, young steelhead use pools and faster water in riffles and runs/ step-runs, while coho salmon use primarily pools.

Densities of yearling steelhead are usually regulated by water depth and the amount of escape cover that exists during low-flow periods of the year (July-October). In most small coastal streams, availability of this "maintenance habitat" provided by depth and cover appears to determine the number of smolts produced by the smaller streams and tributaries. The abundance of food (aquatic insects and terrestrial insects that fall into the stream) and fast-water feeding positions for capture of drifting insects in "growth habitat" determines the size of these smolts. Aquatic insect production is maximized in unshaded, high gradient riffles dominated by relatively unembedded substrate larger than about 4 inches in diameter.

Yearling steelhead growth usually shows a large increase during the period of March through June. Larger steelhead then smolt. For steelhead that stay a second summer, summer growth is very slight in many tributaries (or even negative in terms of weight) as flow reductions eliminate fast-water feeding areas and reduce insect production. A growth period may occur in fall and early winter after leaf-drop of riparian trees, after increased streamflow from early storms, and before water temperatures decline below about 48ºF or water clarity becomes too turbid for feeding. The "growth habitat" provided by higher flows in spring and fall (or in summer for the mainstem River) is very important, since ocean survival to adulthood increases exponentially with smolt size.

Of the two size-class categories of juvenile steelhead captured during fall sampling, the smaller size class was those juveniles less than (<) 75 mm (3 inches) Standard Length (SL) because those would likely require another growing season before smolting. The larger size class included juveniles 75 mm SL or greater (=>) and constituted fish that are called "smolt size" because they will out-migrate the following spring. Smolt size was based on out-migrant smolt trapping carried out by Smith and Alley in 1987-88 in the lower San Lorenzo River. This size class may include fast growing young-of-the-year steelhead inhabiting the mainstem River or lower reaches of larger tributaries and yearlings and older fish inhabiting tributaries and the mainstem River.

Overwintering Habitat. Deeper pools, undercut banks, side channels, and especially large, unembedded rocks provide shelter for fish against the high winter flows. In some years, such as 1982, extreme floods may make overwintering habitat the critical factor in steelhead production. In most years, however, if the pools have sufficient larger boulders, large woody debris or undercut banks to provide summer rearing habitat, then these elements are sufficient to protect juvenile steelhead and coho salmon against winter flows.

Project Purpose and General Study Approach

The intent of the fall, 2001 fish sampling and habitat evaluation was to compare 2001 production of juvenile steelhead and rearing habitat conditions with those in 1981 and 1994-2000 in the San Lorenzo River, a major river drainage flowing into the northern Monterey Bay. Steelhead density at each of 14 mainstem sampling sites and habitat proportions obtained from habitat typing in fall of 2000 were used to estimate juvenile production in 13 reaches of the River. Sampling also included 20 tributary sites representing 20 reaches of 9 tributaries of the San Lorenzo River. Densities determined by habitat type were combined with habitat proportion data by reach to estimate juvenile steelhead production in the mainstem River and its major tributaries. An estimate of an index of adults returning to the system was extrapolated from mainstem and tributary juvenile steelhead production by use of a model based on survival rates of three juvenile size classes.

Habitat conditions were assessed from estimates of streamflow, escape cover, channel width, water depth, streambed substrate composition, substrate embeddedness and tree canopy.

METHODOLOGY

Fish Population Monitoring- Methods

For management purposes, we need to know if habitat quality is improving or not and where. We need to know where most of the fish are produced, both YOY's and smolt-sized fish, or which reaches have the highest potential, before we may direct management efforts. We need to know how the juvenile population is responding to habitat changes. The juvenile production estimates for reaches that result from sampling average quality habitat, in our judgment, provided sufficient accuracy to detect trends in annual production and changes in size classes and age classes in relation to habitat quality (increased smolt-sized juveniles when escape cover and water depth increase). This sampling regime has allowed comparisons in juvenile production and habitat quality between reaches within tributaries and the mainstem, between tributaries themselves, and between the 9 major tributaries and the mainstem. Their relative contribution to an index of adults was also forthcoming. The production estimates have been adequate to detect El Niño impacts from high mortality to overwintering fish, sedimentation and poor oceanic conditions. Sampling has detected changes in juvenile growth rate in response to different an annual baseflow. We have detected improved YOY survival in years when stormflows occurred primarily early in the winter.

The mainstem was divided into 13 reaches, based on past survey work (**Table 1a; Appendix A, Figure 2**). Much of the San Lorenzo River was surveyed during a past water development feasibility study in which general geomorphic differences were observed (**Alley 1993**). This work involved survey and determination of reach boundaries in the mainstem and certain tributaries, including Kings and Newell creeks (**Tables 1a-b; Appendix A, Figure 2**). In past work for the San Lorenzo Valley Water District, Zayante and Bean creeks were surveyed and divided into reaches (**Table 1b; Appendix A, Figure 2**). Previous work for the Scotts Valley Water District required survey of Carbonera Creek and reach determination (**Table 1b; Appendix A, Figure 2**).

In each tributary and the upper mainstem, the uppermost extent of steelhead use was approximated. For the upper San Lorenzo River, Bear and Boulder creeks, topographic maps were used with attention to change in gradient and tributary confluences to designate reach boundaries (**Table 1b; Appendix A, Figure 2**). The uppermost reach boundaries for Bean and Bear creeks were based on a steep gradient change seen on the topographic map, indicative of passage problems. Known barriers set the upper reach boundaries in Carbonera, Fall, Newell, Boulder and Kings creeks. The extent of perennial stream channel in most years was the basis for setting boundaries on Branciforte and Zayante creeks. Steelhead estimates in Zayante Creek stopped at the Mt. Charlie Gulch confluence, although steelhead habitat exists above this point in Zayante Creek and Mt. Charlie Gulch in many years. Steelhead habitat in the Zayante tributary, Lompico Creek, was not included in juvenile steelhead production. No sampling occurred there, with the fish usage of Lompico Creek subject to difficult access and summer surface water diversion. A bedrock chute near the creekmouth was marginally passable with a fish ladder. But a landowner had added an instream wall to worsen fish passage.

Sampling sites were representative of their reaches in regard to habitat depth, length and escape cover according to 2000 conditions. In 2001 there was insufficient time to do habitat typing prior to sampling. Since the winter had been mild without significant channel-changing stormflow, it was decided that sites chosen in 2000 remained representative in 2001. With mild storms, it was unlikely that unusual scour patterns had developed. The fact that streamflow was less in 2001 should not have changed the relative quality of habitats in reaches because it affected habitat depth similarly throughout the reach. Therefore, the same sampling sites used in 2000 were repeated in 2001 with two exceptions. The 2001 scope did not include sampling sites in Reach 0A below Highway 1. The upper Bean Creek site (14c) was dry in 2001. Therefore, the site used in 1999 was repeated in 2001. However, habitat comparisons between years for upper Bean Creek were weakened. In some cases, the same habitats were sampled in 2001 as had been in 1998-2000.

Pool habitat was mostly censused by underwater observation in the mainstem River in 1998-2001. Most pools were too deep to electrofish in Reaches 1-9, between Paradise Park and the Boulder Creek confluence. Shallow pools were electrofished in Reaches 0 and 7, with additional snorkel-censusing in Reach 7. All habitat at a site that could be effectively electrofished was censused by electrofishing.

Branciforte, Carbonera, Zayante, Bean, Fall, Newell, Boulder, Bear and Kings creeks were the 9 major tributaries sampled in the San Lorenzo River drainage. Refer to **Table 1c, Appendix A, Figure 2** and page 2 for a list sampling sites and locations. Steelhead inhabit other tributaries, but these 9 are the important ones that provide a conservative estimate of juvenile population size and annual trends in juvenile numbers and habitat changes. Other tributaries known to contain steelhead from past sampling and observation include (from lower to upper watershed) Eagle Creek in Henry Cowell State Park, Lockhart Gulch, Lompico Creek, Mountain Charlie Gulch in the upper Zayante Creek drainage, Love Creek, Clear Creek, Two Bar Creek and Jamison Creek. Other creeks likely to provide steelhead access and perennial habitat include Glen Canyon and Granite creeks in the Branciforte system, Powder Mill Creek, Gold Gulch and two small tributaries to Bean Creek- Ruins and Mackenzie creeks. This list is not exhaustive for steelhead. Resident rainbow trout undoubtedly exist upstream of steelhead migrational barriers in some creeks.

Based on the habitat typing carried out in each reach prior to the fish sampling effort in 2000, representative habitat units were selected with average habitat quality values in terms of water depth and escape cover to determine fish densities by habitat type. In mainstem reaches of the lower and middle River, riffles and runs that were close to the average width and depth for the reach were sampled by electrofishing. Pools in these reaches were divided into long pools (greater than 200 feet long) and short pools (less than 200 feet) and at least one pool of each size class was either snorkel censused or electrofished. In these lower and middle mainstem reaches, most fish were in the fastwater habitat and not the pools. Some of the pools are hundreds of feet long with very few juveniles, except for a few at the head of the habitat.

For reaches in the upper River and all tributaries, the location of representative pools with average habitat quality in terms of water depth and escape cover determined the non-pool habitat that was sampled. Pools were deemed representative if they had escape cover ratios and water depths similar to the average values for all pools in the half-mile segment that was habitat typed within the reach. Therefore, pools that were much deeper or much shallower than average or had much less or much more escape cover than average were not sampled. Once the pools were chosen for electrofishing, adjacent riffles, step-runs, runs and glides were sampled, as well. In these smaller channel situations, these latter habitat types showed great similarity between individual habitats of those types. Namely, riffles runs, step-runs and glides were all about the same in depth and escape cover. Since habitat conditions may change from year to year and locations of individual habitat units may shift depending on winter storm conditions, sampled units may also change. The assumption in this method is that fish sampling of representative habitat will reflect the mean habitat quality for the reach and provide average fish densities for specific habitat types throughout the reach. The assumption here is that there is a correlation between fish density and habitat quality in that better habitat has more fish. Past modeling has indicated that densities of yearling-sized juveniles are well correlated with water depth and escape cover (Smith 1984). The fish density for each habitat type was estimated as the number of fish per linear foot of that habitat type. Thus, the number of fish estimated for each censused pool in the reach was divided by the linear feet of habitat sampled.

Once fish densities were determined for representative habitat types within a reach, they were incorporated with the proportion of habitat types within the reach to extrapolate to a fish population estimate for the reach. Then population estimates for tributaries or segments of the mainstem by adding up the reach estimates.

Consistency of Data Collection Techniques in 1994 through 2001

Habitat parameters were measured at the monitoring sites consistent with methods used in 1981 and 1994-2000. Donald Alley, the principal investigator and data collector in 1994-2001, had also collected the fish and habitat data at 9 of the 18 San Lorenzo River sites and 5 of the 8 tributary sites in the 1981 study during the data collection for the County Water Master Plan (Smith 1982). His qualitative estimates of embeddedness, streambed composition and habitat types were calibrated to be consistent with those of Dr. Smith, the primary investigator for the 1981 sampling program. Mr. Alley's method of measuring escape cover for yearling-sized and larger steelhead was consistent through the years. Regarding electrofishing, in 1995 a block net was used only at the lower end of each habitat at only Site 2 in the Gorge. In 1994 and 1995, block nets were not used for the sake of consistency with 1981 techniques. From 1996 onward, block nets were used to partition off habitats at all electrofishing sites. This prevented steelhead escapement. A multiple pass method was used in each habitat with at least three passes.

From 1998 onward, underwater visual (snorkel) censusing was incorporated with electrofishing so that pool habitat in the mainstem River, which had been electrofished in past years, could be effectively censused despite it being too deep in 1998 (a high-flow year) for backpack electrofishing. Snorkel censusing was also used to obtain density estimates in deeper pools previously unsampled prior to

1998 at Sites 2, 3, 7, 8 and 9, in an effort to increase the accuracy of production estimates. A more realistic juvenile production estimate and predictions of adult returns were made with snorkel-censusing of pool habitat in the mainstem River.

Table 1a. Defined Reaches on the Mainstem San Lorenzo River. (Refer to Appendix A for map designations.)

Reach #	Reach Boundaries	Reach Length (ft)
0	Water Street to Tait Street Diversion CM0.92 – CM1.92	5,277
1	Highway 1 to Buckeye Trail Crossing CM1.92 - CM4.73	14,837
2	Buckeye Trail Crossing to the Upper End of the Wide Channel Representation on the Felton USGS Quad Map CM4.73 - CM6.42	8,923
3	From Beginning of Narrow Channel Representation in the Gorge to the Beginning of the Gorge (below the Eagle Creek Confluence) CM6.42 - CM7.50	5,702
4	From the Beginning of the Gorge to Felton Diversion Dam CM7.50 - CM9.12	8,554
5	Felton Diversion Dam to Zayante Creek Confluence CM9.12 - CM9.50	2,026
6	Zayante Creek Confluence to Newell Creek Confluence CM9.50 - CM12.88	17,846
7	Newell Creek Confluence to Bend North of Ben Lomond CM12.88 - CM14.54	8,765
8	Bend North of Ben Lomond to Clear Creek Confluence in Brookdale CM14.54 - CM16.27	9,138
9	Clear Creek Confluence to Boulder Creek Confluence CM16.27 - CM18.38	11,137
10	Boulder Creek Confluence to Kings Creek Confluence CM18.38 - CM20.88	13,200
11	Kings Creek Confluence to San Lorenzo Park Bridge Crossing CM20.88 - CM24.23	17,688
12	San Lorenzo Park Bridge to Gradient Change, North of Waterman Gap CM24.23 - CM26.73	13,200
	TOTAL	136,293 (25.8 miles)

Table 1b. Defined Reaches For Sampled Tributaries of the San Lorenzo River. (Appendix A provides map designations.)

Creek- Reach #	Reach Boundaries (Downstream to Upstream)	Reach Length (ft)
Zayante 13a	San Lorenzo River Confluence to Bean Creek Confluence CM0.0-CM0.61	3,221
13b	Bean Creek Confluence to Tributary Trans-porting Sediment from Santa Cruz Aggregate CM0.61-CM2.44	9,662
13c	Santa Cruz Aggregate Tributary to Lompico Creek Confluence CM2.44-CM3.09	3,432
13d	Lompico Creek Confluence to Mt. Charlie Creek Confluence CM3.09-CM5.72	13,886
Bean 14a	Zayante Creek Confluence to Mt. Hermon Road Overpass CM0.0-CM1.27	6,706
14b	Mt. Hermon Road Overpass to Ruins Creek Confluence CM1.27-CM2.15	4,646
14c	Ruins Creek Confluence to Gradient Change Above the Second Glenwood Road Crossing CM2.15-CM5.45 (with 0.33 miles dewatered)	17,424
Fall 15	San Lorenzo River Confluence to Boulder Falls CM0.0-CM1.58	8,342
Newell 16	San Lorenzo River Confluence to Bedrock Falls CM0.0-CM1.04	5,491
Boulder 17a	San Lorenzo River Confluence to Foreman Creek Confluence CM0.0-CM0.85	4,488
17b	Foreman Creek Confluence to Narrowing of Gorge Adjacent Forest Springs CM0.85-CM2.0	6,072
17c	Narrow Gorge to Bedrock Chute At Kings Highway Junction with Big Basin Way CM2.0-CM3.46	7,709
Bear 18a	San Lorenzo River Confluence to Unnamed Tributary at Narrowing of the Canyon Above Bear Creek Country Club CM0.0-CM2.42	12,778
18b	Narrowing of the Canyon to the Deer Creek Confluence CM2.42-CM4.69	11,986
Kings 19a	San Lorenzo River Confluence to Unnamed Tributary at Fragmented Dam Abutment CM0.0-CM2.04	10,771
19b	Fragmented Dam to Bedrock-Boulder Cascade CM2.04-CM3.73	8,923

Table 1b. Defined Reaches For Sampled Tributaries of the San Lorenzo River. (Appendix A provides map designations.)

Carbonera 20a	Branciforte Creek Confluence to Old Road Crossing and Gradient Increase CM0.0-CM1.38	7,293
20b	Old Road Crossing to Moose Lodge Falls CM1.38-CM3.39	10,635
Branciforte 21a	Carbonera Creek Confluence to Granite Creek Confluence CM1.12-CM3.04	10,138
21b	Granite Creek Confluence to Tie Gulch Confluence CM3.04-CM5.73	14,203

	TOTAL	177,806 (33.7 miles)

Table 1c. Sampling Sites Used to Estimate Densities of Steelhead by Reach on the Mainstem San Lorenzo River and Tributaries, 2000.

Reach #	Sampling Site # -Channel Mile	<u>MAINSTEM SITES</u> Location of Sampling Sites
0	0a –CM1.6	Above Water Street Bridge
0	0b –CM2.3	Above Highway 1 Bridge
1	1 -CM3.8	Paradise Park
2	2 -CM5.7	Lower Gorge at Rincon Trail Access
3	3 -CM7.4	Upper End of the Gorge
4	4 -CM8.9	Downstream of the Cowell Park Entrance Bridge
5	5 -CM9.3	Downstream of Zayante Creek Confluence
6	6 -CM10.4	Below Fall Creek Confluence
7	7 -CM13.8	Above Lower Highway 9 Crossing in Ben Lomond
8	8 -CM15.9	Upstream of the Larkspur Road (Brookdale)
9	9 -CM18.0	Downstream of Boulder Creek Confluence
10	10 -CM20.7	Below Kings Creek Confluence
11	11 -CM22.3	Downstream of Teilh Road, Riverside Grove
12	12a-CM24.7	Downstream of Waterman Gap and Highway 9
	12b-CM25.4	Waterman Gap Upstream of Highway 9

Table 1c. Sampling Sites Used to Estimate Densities of Steelhead by Reach (Cont'd) on the Mainstem San Lorenzo River and Tributaries, 2000.

Reach #	Sampling Site # -Channel Mile	TRIBUTARY SITES Location of Sampling Sites
13a	13a-CM0.3	Zayante Creek Upstream of Conference Drive Bridge
13b	13b-CM1.6	Zayante Creek Above First Zayante Rd Xing
13c	13c-CM2.8	Zayante Creek downstream of Zayante School Road Intersection with E. Zayante Road
13d	13d-CM4.1	Zayante Creek upstream of Third Bridge Crossing of East Zayante Road After Lompico Creek Confluence
14a	14a-CM0.1	Bean Creek Upstream of Zayante Creek Confluence
14b	14b-CM1.8	Bean Creek Below Lockhart Gulch Road
14c	14c-CM4.5	Bean Creek 1/4-mile Above Mackenzie Creek Confluence and Below Golpher Gulch Rd.
15	15 -CM0.8	Fall Creek, Above and Below Wooden Bridge
16	16 -CM0.5	Newell Creek, Upstream of Glen Arbor Road Bridge
17a	17a-CM0.2	Boulder Creek Just Upstream of Highway 9
17b	17b-CM1.6	Boulder Creek Below Bracken Brae Creek Confluence
17c	17c-CM2.6	Boulder Creek, Downstream of Jamison Creek
18a	18a-CM1.5	Bear Creek, Just Upstream of Hopkins Gulch
18b	18b-CM4.2	Bear Creek, Downstream of Bear Creek Road Bridge and Deer Creek Confluence
19a	19a-CM0.8	Kings Creek, Upstream of First Kings Creek Road Bridge
19b	19b-CM2.5	Kings Creek, 0.2 miles Above Boy Scout Camp and Upstream of the Second Kings Creek Road Bridge
20a	20a-CM0.7	Carbonera Creek, Upstream of Health Services Complex
20b	20b-CM1.9	Downstream of Buelah Park Trail
21a	21a-CM2.8	Branciforte Creek, Downstream of Granite Creek Confluence
21b	21b-CM4.6	Upstream of Granite Creek Confluence and Happy Valley School

Juvenile Steelhead Densities at Sampling Sites - Methods

Electrofishing was used to determine densities according to two juvenile age classes and three size classes in all stream reaches in 1997 and all but mainstem Reaches 1-9 from 1998 onward. Electrofishing mortality rate has been less than 0.05% with our crew over the years. For the nine mainstem reaches included in Table 2, underwater censusing of deeper pools was incorporated into density estimates with electrofishing data from more shallow habitats. Pool censusing in Reach 5 was based on snorkeling results from Reach 4. Visual censusing was judged inappropriate in other habitats because it would be inaccurate in fastwater habitat in the mainstem and in 80-90% of the habitat in tributaries. Seventy-seven percent of the pools sampled in tributaries in 2001 had more than 20 fish in them. Most tributary sites are well shaded and many pools have substantial escape cover, making it very difficult to count all of the juveniles, much less divide them into size and age classes. Riffles, step-runs, runs and glides are too shallow to snorkel census in tributaries.

Estimation of juvenile steelhead densities by site was based on either the 2- (**Knable 1978**) or 3-pass depletion method of electrofishing in 1994-95 and the 3-pass method from 1996 onward. Block nets were used at all sites from 1996 onward. The electrofished portion of the 15 mainstem sites in 2001 averaged 250 feet per site, totaling 3,757 linear feet sampled. This consisted of 2.7% of the estimated mainstem steelhead habitat beginning at the rivermouth (26.7 miles). Eighteen deep pools were censused by underwater observation, totaling 4,883 linear feet and consisting of 3.5% of the estimated mainstem habitat (**Table 2**). Therefore, a combined 6.2% of the mainstem was censused.

Snorkeling was used to visually census juvenile steelhead by underwater observation in pool habitat in the lower and middle, mainstem River (Reaches 1-4; 6-9). This method was used in deeper pools and their associated glides that could not be electrofished. Fish densities determined by snorkeling were used to represent deep pool habitat and their associated glides.

In larger rivers of northern California, density estimates from electrofishing are commonly combined with those determined by underwater observation in habitats too deep for electrofishing. Ideally, underwater censusing would be calibrated to electrofishing data in habitat where capture approached 100%. Calibration was originally attempted by Hankin and Reeves (1988) for small trout streams. Their intent was to substitute snorkel censusing for electrofishing. However, attempts at calibration of the two methods of censusing in large, deep pools of the mainstem San Lorenzo River was judged impractical, beyond the scope of the study and probably would be inadequate.

In our judgment, based on experience with electrofishing from a boat, the deep pools where visual censusing was used could not be effectively electrofished in most reaches. There would be no assurance that counts obtained by electrofishing would be any more accurate than visual counts. Even with crews of 10 people or more and motor-powered rafts equipped with special electrofishing devices, electrofishing would probably not be more than 80 percent successful in capturing all of the steelhead in pools that were hundreds of feet long and 50-100 feet wide. Factors to consider in such a calibration attempt would be the difficulty of hauling rafts or barges into sampling sites, the danger of operating electrofishing devices on small flotation devices and the excessive cost of labor and equipment necessary to sample deep pools in the San Lorenzo River by electrofishing. Electrofishing from the streambank would have been futile with pool widths of 30 to 100 feet and maximum water depths commonly 8 feet or greater. In conclusion, underwater snorkeling was the only practical way to census pool habitat in the lower and middle San Lorenzo River in 1998, and it yielded realistic density estimates in deeper pool habitat. The principal investigator in this study was a pioneer in underwater snorkel censusing in the 1970's, having developed the original methodology. Prior to snorkel-censusing that began in the San Lorenzo River in 1998, he had more than 2,000 hours of experience in underwater observations and visual censusing of Sierran stream fishes, including juvenile steelhead/rainbow trout and chinook salmon (*Oncorhynchus tshawytscha*).

Two divers were used in snorkel censusing. In wide pools, divers divided the channel longitudinally into counting lanes, combining their totals after traversing the habitat in an upstream direction. Divers would warn each other of juveniles being displaced into the other's counting lane to prevent double-counting. For juveniles near the boundaries of adjacent counting lanes, divers would verbally agree to who would include them in their tallies. In narrower pools, divers would alternate passes through the pool to obtain replicates to be averaged. In most pools, three replicate passes were accomplished per pool. The average number of steelhead observed per pass in each age and size category became the density estimate. Visual censusing of deeper pools occurred after electrofishing of the sites. The relative proportions of steelhead in the three Size Classes obtained from electrofishing were considered in dividing visually censused steelhead into size and age classes. In Reaches 1-4, most juveniles were greater than 75 mm SL, and yearlings were considerably larger than Y-O-Y fish. Therefore, it was relatively easy to separate fish into size and age classes. In Reaches 6-9, more juveniles were approximately 75 mm SL, leading to a small error for some individuals in deciding size class division between Classes 1 and 2. However, there was no difficulty in distinguishing age classes.

Visual censusing offered realistic density estimates of steelhead in deeper mainstem pools. It was the only practical way to inventory such pools, which were mostly bedrock- or boulder- scoured and having limited escape cover. Visibility was 15 feet or more, making the streambed and counting lanes observable. Very few steelhead used these pools in 1999-2001, less so than in 1998 when mainstem baseflow was considerably higher (minimum of 30 cubic feet per second at the Big Trees Gage compared to approximately 20 cfs or less in later years).

Steelhead numbers were visually censused for two size classes of pools. There were short pools less than approximately 200 feet in length and those more than approximately 200 feet. Juvenile densities in censused pools were extrapolated to other pools in their respective size categories. Steelhead were censused by size and age class, as in electrofishing. As in previous years, if less than 20 juveniles were observed in a pool, the maximum number observed in an age/size class on a pass was used as the estimate. When 20 or more juveniles were observed, the average of the three passes was used as the estimate.

The same 9 tributaries were sampled in 2001 as in 1998-2000. The tributaries were Branciforte, Carbonera, Zayante, Bean, Fall, Newell, Boulder, Bear and Kings. The sampling effort included 20 tributary sites with one site per reach. The 20 sites averaged 316 feet per site, totaling 6,332 feet and

3.6% of the 33.7 miles of estimated habitat in the nine tributaries.

Table 2. Number of Pools and Associated Glides Censused per Mainstem Reach in Linear Feet by Underwater Snorkeling Versus Number of Habitats and Length Electrofished in the San Lorenzo River, 2001.

Reach #	# of Pools Snorkeled	Linear Feet Snorkeled	# of Habitats Electrofished	Linear Feet Electrofished
Lower River				
0	0	0	3	347
1	3	741	2	240
2	3	870	5	368
3	3	354	2	133
4	2	350	3	277
5	0	0	3	254
Middle River				
6	2	1,092	3	244
7	1	297	5	311
8	2	571	2	182
9	2	608	3	295
Upper River				
10	0	0	4	415
11	0	0	4	359
12	0	0	9	332
Total	18	4,883	48	3,757

Age and Size Class Divisions

With electrofishing data, the young-of-the-year age (Y-O-Y) class was separated from the yearling and older age class in each habitat, based on the site specific break in the length-frequency distribution (histogram) of fish lengths lumped into 5 mm groupings. Density estimates of age classes in each habitat type were determined by the standard depletion model used with multiple pass capture data. Densities were expressed in fish per 100 feet of channel. Density estimates are measured in the lowest baseflow period of the year when juvenile salmonids remain in specific habitats without up or downstream movement. Density is typically provided per channel length by convention and convenience. Channel length may be accurately measured relatively quickly. If the density measure is consistent from year to year, valid comparisons may be made.

Depletion estimates of juvenile steelhead density were also applied separately to two size categories in each habitat at each site. The numbers of fish in Size Class 1 and the combined Classes 2 and 3 were recorded for each pass. The size class boundary between Size Classes 1 and 2 was 75 mm Standard Length (SL) (3 inches) because fish smaller than this would probably spend another spring, summer and fall in the stream before smolting and entering the ocean the following winter and spring. Fish captured during fall sampling that were larger than 75 mm SL would likely smolt the very next spring to enter the ocean.

The depletion method estimated the number of fish in each habitat in two categories; those less than (<) 75 mm SL (Class 1) and those equal to or greater than (=>) 75 mm SL (Classes 2 and 3). Then, the number of juveniles => 75 mm SL (Class 2) was estimated separately from the juveniles => 150 mm SL (Class 3) in each habitat sampled. This was done by multiplying the proportion of each size class (Class 2 and 3 separately) in the group of captured fish by the estimate of fish density for all fish => 75 mm SL. A density estimate for each habitat type at each site was then determined for each size class. Densities in each habitat of a type were added together and divided by the total length of \that habitat type to obtain a density estimate by habitat type. A predicted index of returning adults was obtained from juvenile size class densities for each sampled reach, using the Dettman population model (**Kelley and Dettman 1987**). To do this, all three size class densities were entered separately as juveniles per foot for each habitat type along with the number of feet of each habitat type per reach

In the lower mainstem San Lorenzo River, many young-of-the-year steelhead reached the Size Class 2 category in just one growing season, as did some in the larger tributaries. In the current monitoring report, sampling site densities were compared for the latest four years by size class and age class (1997-2001). Previous monitoring reports covered earlier years of data. At each sampling site, habitat types were sampled separately and fish numbers were combined and divided by the stream length of the site for annual comparisons. Size Classes 2 and 3 were combined for annual comparisons.

Juvenile Densities Determined by Reach in the Mainstem San Lorenzo River and Tributaries- Methods

For comparison in 1995-96, it was assumed that sampled habitat types were representative of habitat found in the defined reaches and were in the same proportions at the site as existed in the reach. From 1997 onward, habitats to be sampled were chosen as representative with their depths and amount of escape cover approximating reach segment averages derived from habitat-typing.

The sampling design for 1996 and before was intended to assess trends in juvenile steelhead numbers by comparing monitoring site densities to previous years. This was done by sampling the same locations and habitat types originally sampled in 1981. Steelhead densities at each sampling site were extrapolated to reach numbers in the mainstem San Lorenzo River. The sampled habitat length was divided into the reach length. This quotient was then multiplied by the number of juveniles of each size class present in the sample site to obtain reach totals.

Prior to 1997, the simplifying assumption was that the proportion of sampled habitat types was consistent with habitat proportions in the reach. This was not completely accurate. From 1997 onward, accuracy of measuring juvenile steelhead production was increased at the expense of making close comparisons with previous years' sampling results at identical sites. Since 1998, accuracy was increased by adding a sampling site in Reach 5.

Since 1997, habitat-typing in the mainstem River improved our estimate of habitat proportions by reach for more accurate fish population estimates. Approximately 1/2 mile or more of stream was habitat-typed in the vicinity of each sampling site. Beginning in 1998, tributaries were divided into reaches with 1/2-mile segments surveyed in each so that representative habitats were sampled within each segment, based on depth and escape cover considerations. In 2001, the habitat typing results from 2000 were used.

The proportion of habitat types within each 1/2-mile segment represented habitat proportions for the entire reach. Fish densities determined by size class and age class in each sampled habitat type were multiplied by the number of feet of that habitat type estimated for the reach. These were densities determined by a combination of electrofishing and visual snorkel censusing from 1998 onward. Then the number of fish estimated in each habitat type was added to those in other habitat types to obtain reach totals. These reach totals were the best estimate that could be obtained with the budgetary constraints that limited the sampling effort. By sampling average habitat quality, it was assumed that approximately average fish densities were detected in specific habitat types for the reach.

From 1998 onward, habitat-typing in 9 tributaries allowed estimation of tributary steelhead densities by reach. Reach densities were extrapolated from steelhead densities by habitat type at representative sampling sites, coupled with habitat proportions within reaches. In 2001, the habitat typing results from 2000 were used.

Index of Returning Adult Steelhead Resulting from Natural Production of Juveniles - Methods

For purposes of comparison from 1981 and 1994 onward, the predicted index of the annual number of returning adults was determined for the mainstem River from estimates of juvenile densities. This would indicate the trend in adult steelhead populations resulting from natural smolt production. The predicted number of adults returning from tributary juvenile production was also determined from 1998 onward, allowing comparisons of the indices in tributaries and overall for tributaries and the mainstem. Steelhead survival in the ocean also affects returning numbers and will be discussed later. Production of adults from hatchery plantings was not accurately available and excluded in estimating the adult index.

The index of predicted adult returns was based on survival rate of different juvenile age/size classes returning as adults to Waddell Creek during the period, 1933-42 (Shapovalov and Taft 1954). It was found that steelhead survival rate to spawning adults increased exponentially with increasing size of steelhead smolts (**J. Smith, personal communication**). Shapovalov and Taft marked and aged down migrant smolts and recaptured them as adults to allow Smith to develop the relationship. Dettman (Kelley and Dettman 1987) developed a model based on the Waddell Creek relationship of average size of each age class as smolts and survival to returning adult. He estimated survival of juveniles from a reasonable estimate of densities in Waddell Creek in the fall to the down-migrant smolt stage for the different age classes. The Waddell Creek relationship was:

$$\textbf{Fraction of Survival} = (0.067)\, e^{(0.025)(\text{Fork Length of smolt})}$$

This relationship estimates the fraction of survival for fish of a particular fork length. The Dettman model required an estimate of juvenile steelhead densities by age class in the fall of the year. The size classes were divided according to year class sizes typically found in Waddell Creek, based on Dr. Jerry Smith's experience. Young-of- the-year fish were up to 75 mm Standard Length. Yearlings were from 75 mm to 150 mm Standard Length. Steelhead were included in the 2+ age class if larger than 150 mm Standard Length. Fork Length equals 1.1 times the Standard Length.

Number of juvenile steelhead by age/size class per foot of each habitat type in each reach was inputted to the Dettman model to predict number of returning adults, using the Waddell Creek rate of return in the 1933-42 period. Returning adults consisted of two categories. One category was first time spawners. The other was the total number of returning adults expected with a 20% repeat spawning rate. The model emphasized the increased survival rate expected for larger size classes of juvenile steelhead.

To make a more realistic estimate of returning adults from juveniles present, the estimates derived from the Dettman model were reduced by 50%, based on an estimate of returning adult steelhead to Waddell Creek in 1991-92 (**Smith 1992**). Smith estimated that roughly 248 adults returned to spawn, based on his trapping of up-migrating adult steelhead, tagging, sampling upstream of the trap for recaptures, and trapping down migrants for recaptures. This estimate was approximately half of the average return of 432 adults during the Shapovalov and Taft study (**1954**) that encompassed the years, 1933-42, forming the basis for a 50% reduction factor. An assumption was that the reduction in adult returns in 1992 that required a correction factor had resulted from reduced ocean survival. Another underlying assumption in the 50% reduction factor was that rearing habitat in Waddell Creek is currently capable of producing 1930's levels of juvenile smolts over the long term. This was judged likely by Dr. Smith (**personal communication**). It must be realized that ocean survival may fluctuate from year to year, thus causing the correction factor to fluctuate. However, if the same assumptions are applied to annual juvenile production, the adult index allows us to assess the relative potential of the juvenile population to produce adults each year. This is a valuable comparison.

Smith noted that adults returning to Waddell Creek in 1991-92 came from juvenile production in

1989-91, at the end of a five-year drought. Further, additional streamflow reduction and habitat degradation came from summer water diversion that did not exist in the 1930's. Therefore, juvenile production leading to adults in 1991-92 was probably much less than the average juvenile production in the 1930's. Therefore, the average return estimate of 432 adults in the 1930's may be higher than expected from juveniles produced in drought years of the 1930's. Limited supporting evidence is that the first recorded water year on the San Lorenzo River (record beginning in 1937) that produced similar acre-feet of streamflow as the drought years of 1987-92 was water year 1938-39. The adult return checked through the upstream trap on Waddell Creek in 1941-42 from primarily juveniles produced in the 1938-39 water year was 377 adults.

The range of estimates of adult returns during the earlier study was 373-539 adults. A less conservative reduction factor in terms of preventing an overestimate of adult returns, but perhaps more realistic one, may be 0.33 (1 - 248/373) or 33% instead of 50%, using the ratio of Smith's estimated adult return divided by the lowest estimated adult return during the 1932-42 period. However, 0.33 may be too small a reduction factor because during drought in 1989-90, there was surface water diversion to reduce juvenile production that was absent during drought in the 1930's.

The model provides an annual adult index for comparison, regardless of whether the reduction factor should be 50% or 33% or something else. It is important to note that our annually applied model uses the same constant survival rates of juveniles to adults, and our correction factor is also constant. However, in reality there are annual fluctuations in ocean survival that are impossible to account for. In addition, sea lions and harbor seals congregate at the mouth of the San Lorenzo River, which may increase the mortality of steelhead adults entering the River compared to Waddell Creek, particularly in drier years.

The aforementioned method of estimating returning adult steelhead was more practical than trying to capture down-migrant smolts. Estimates of adult numbers from smolt numbers captured by down-migrant smolt trapping would be prohibitively expensive and inefficient because down-migrant smolt trapping would require nightly trapping activities over a period of at least two months in the spring. Smolt trapping would be very inefficient during stormflows when down-migration would increase. Unless a very permanent trapping facility was constructed, the fish trap would be very ineffective during storm events. Down-migrant adult trapping to estimate numbers of kelts returning to the ocean after spawning would not accurately indicate numbers of adult spawners because many adults do not survive to down-migrate after spawning. Trapping of down-migrant adults would require the same expensive, intensive effort required for down-migrant smolt trapping, with the associated ineffectiveness during stormflows. An added negative aspect would be potentially high fish mortality unless the trap was emptied through the night, every night.

In recent years, the Monterey Bay Salmon and Trout Project has operated a trap for spawning adults at the inflatable Felton Diversion Dam, in cooperation with the City of Santa Cruz. Adults that use the fish ladder may be trapped there. In drier winters without major storm events and high baseflows, the trap may capture a major portion of the adults passing that point. However, the City is required to deflate the dam every few days. In wetter years and during major flood flows the trap is less effective because the adults bypass the fish ladder. An index of adult returns could be estimated from trapping data, based on the number of days the trap was operated and the number of days of likely upstream migration for each year. The assumption would be that trapping rate on the days that the trap was operational was similar to the migration rate on days that the trap was not working. This may be only partially accurate.

Habitat Assessment- Methods

Classification of Habitat Types and Measurement of Habitat Characteristics

Approximately 1/2-mile or more of stream was last surveyed and habitat-typed in 2000 in the vicinity of each sampling site in the mainstem River and tributaries. The proportion of habitat types in the surveyed sections was used to extrapolate to the habitat proportions for the entire reach. Habitat comparisons were made from 1997 onward in mainstem reaches at electrofished sites and in 1/2-mile or more, habitat-typed segments within reaches. Tributary results were compared from 1998 onward. A total of 53,859 feet (10.2 miles, averaging 0.7 mile/ reach) were habitat-typed in the mainstem in August and September 2000, which included the same 13 reach-segments examined in 1998 and the additional segment added in 1999. The additional segment represented the reach between the Water Street Bridge, where the lagoon/estuary ended, and the Tait Street Diversion structure on the mainstem. Some 7,255 feet of habitat existed in the 1-mile Reach 0 due to it having considerable split-channels.

Tributaries were divided into reaches with approximately 1/2-mile segments habitat-typed in each in 2000. A total of 53,412 (10.1 miles) were habitat-typed in 21 reach-segments of tributaries to assess habitat conditions. In 1999, an additional segment was added on Branciforte Creek between the Carbonera and Glen Canyon creek confluences, thus, dividing the former Reach 21a into two reaches. Habitat conditions at tributary sampling sites were compared between years where the same or similar habitats were sampled.

Habitat types were classified according to the categories outlined in the California Salmonid Stream Habitat Restoration Manual (**Flosi et al. 1998**). A modified CDFG Level III habitat inventory method was used. Some habitat characteristics were estimated according to the manual's guidelines, including length, width, mean depth, maximum depth, shelter rating and tree canopy (tributaries only in 1998). More data were collected for escape cover than required by the manual.

Measurement of Habitat Parameters - Methods

As part of the habitat typing method used at sampling sites only in 2001, visual estimates of substrate composition and embeddedness are made. The observer looks at the habitat and makes mental estimates based on what he sees with his trained eye. Therefore, these estimates are somewhat subjective, with consistency between data collectors requiring calibration from one to the other. An assumption is that the same data collector will be consistent in visual estimates from habitat to habitat and from year to year. Another assumption is that if more than one data collector contributes to the same study, the original observer trains the others to be consistent with the original data collector's visual estimates. In this study, Alley has collected all habitat data through the years except in 1999 and 2000, when 6 reaches were assigned to Walter Heady in both years. Heady was calibrated to Alley for visual estimates each year.

Fine sediment was visually estimated as particles smaller than approximately 0.08 inches. In the San Lorenzo River, there is little gradual gradation in particle size between sand and larger substrate, making visual estimates of fines relatively easy. There is generally a shortage of gravel-sized substrate. The comparability of these visual estimates to data collection via pebble counts would depend on the skill of the visual estimator and the skill of the pebble collectors. Untrained volunteers tend to select larger substrate to pick up and measure during pebble counts, resulting in an overestimate of particle size composition of the streambed. The accuracy of pebble counts is also dependent on sample size. Neither the pebble count nor the visual estimate will provide data for substrate below the streambed surface. The McNeil Sampler may be used for core samples, and results from this method may not comparable to the other methods. The substrate that may be sampled with core sampling is restricted by the diameter of the sampler. Both the pebble count method and the core sampling method are too labor intensive for habitat typing. We do not believe more in-depth estimates than those taken for percent fines during habitat-typing are necessary for purposes of this fishery study. It is best to have annual consistency in data collecting personnel during habitat-typing, however.

From 1999 onward, embeddedness was visually estimated as the percent that cobbles and boulders larger than 150 mm (6 inches) in diameter were buried in finer substrate. Previous to 1999, the cobble range included substrate larger than 100 mm (4 inches). The change in cobble size likely had little effect on embeddedness estimates. The reason the cobble size was increased to 150 mm was because substrate smaller than that probably offered no benefit for fish escape cover, and embeddedness of smaller substrate was not a good indicator of habitat quality for fish.

The previous years' data was not reviewed prior to data collection so as not to bias the latest data collection. Cobbles and boulders larger than approximately 150 mm in diameter provided good, heterogeneous habitat for aquatic insects in riffles and runs and some fish cover if embedded less than 25%. Cobbles and boulders larger than 225 mm provided the best potential fish cover if embedded less than 25%.

Quantitative estimates of tree canopy closure were made in 1994-98 and 2001, using a densiometer. Included in the tree canopy closure measurement were trees growing on slopes considerable distance from the stream. The tree canopy estimates were based on the canopy closure provided by the trees on the day of the measurements, which was probably between 5 and 15% lower than summer conditions because leaf drop had begun by the time of fall sampling. The difference between October conditions and summer conditions depended on the percent of the tree canopy that was deciduous versus evergreen. The percent deciduous value was based on visual estimates of the relative proportion of deciduous canopy closure provided to the stream channel. Tree canopy closure directly determines the amount of solar radiation that reaches the stream on any date of the year, but the relationship changes as the sun angle changes through the seasons. Our measure of canopy closure estimated the percent of blue sky blocked by the vegetative canopy and was not affected by the sun angle.

Greater tree canopy inhibits warming of the water and is critically important in small tributaries. Increased water temperature increases the metabolic rate and food requirements of steelhead. Tree canopy in the range of 75-90% is optimal in the upper River (Reaches 10-12) and tributaries because water temperatures are well within the tolerance range of juvenile steelhead and coho salmon. If reaches with low summer baseflow become unshaded, water temperature rapidly increases. In the San Lorenzo River system, it is important that the tributaries remain well shaded so that tributary inflows to the mainstem are sufficiently cool to prevent excessively high water temperatures in the lower mainstem River (Reaches 1-5), where tree canopy is often in the 50-75% range. There is an inverse relationship between tree canopy and insect production in riffles, which allows faster steelhead growth in larger, mainstem reaches of the San Lorenzo River having deeper, fast-water feeding areas, despite the elevated temperatures and steelhead metabolic rate (and associated food requirements.) However, as fast-water feeding areas diminish in smaller stream channels with less streamflow further up the watershed, high water temperatures may increase steelhead food demands beyond the benefits of greater food production in habitat lacking in fast-water feeding areas. Here is where shade canopy must increase to maintain cooler water temperature and lowered metabolic rate and food requirements of juvenile steelhead.

The escape cover index for each habitat type within sampled sites was quantitatively determined in the same manner in 1994-2001. The importance of escape cover is that the more there is in a habitat, the higher the production of steelhead, particularly for steelhead => 75 mm SL. Water depth itself provides good escape cover when it is 3 feet deep (1 meter) or greater.

At sampling sites, escape cover was measured as the ratio of the linear distance under submerged objects within the habitat type that fish at least 75 mm (3 inches) Standard Length (SL) could hide under, divided by the perimeter distance of the habitat type. This allowed annual comparisons for the few habitats at each site. Reach averages in 1997-2000 for escape cover were determined from habitat-typed segments. For reach segments, escape cover was calculated differently than had been done at sampling sites in order to better compare the overall amount of escape cover in the reach. Cover in reach segments was determined as linear feet of cover under submerged objects per foot of stream channel for each habitat type. Objects of cover included unembedded boulders, submerged woody debris, undercut banks and overhanging tree branches and vines that entered the water. Man-made objects, such as boulder rip-rap, concrete debris and plywood also provided cover. Escape cover constituted areas where fish could be completely hidden from view. This was not a measure of the less effective overhead cover that may be caused by surface turbulence or vegetation hanging over the water but not touching.

Water depth was important because deeper habitat was more utilized by steelhead. Deeper pools were associated with scour objects that often provided escape cover. Mean depth and maximum depth were determined with a dip net handle, graduated in half- foot increments for the first foot and foot increments for the remainder of the handle. Soundings throughout the habitat type were made to estimate mean and maximum depth. Annual comparisons of habitat depth were possible because measurements were taken in the fall of each year. Minimum depth was determined approximately one foot from the stream margin in earlier years. Stream length in 1994-2001 was measured with a hip chain. Width in each year, and length in 1981, was measured with the graduated dip net except in wider habitats of the mainstem. In wider habitats (greater than approximately 20 feet), a range finder was used to measure width.

In 1994 and 1996-97 in the tributary sites and mainstem sites above Boulder Creek, streamflow was estimated mostly visually by measuring the stream cross-sectional area in portions of uniform velocity and estimating the channel velocity for the uniform portions of the cross-sections. For visual estimates, the channel velocity was estimated at several locations across the stream channel by measuring the speed of floating objects and multiplying that quantity by 0.6. The flow volume of all the portions of the cross-section were then added to obtain a streamflow estimate. Estimates were likely within +/- 10-20% of actual streamflow, based on experience. To prevent sampling bias, streamflow was estimated before earlier years' estimates were examined.

From 1995 and 1998 onward, the Marsh McBirney Model 2000 flowmeter was more extensively used at most mainstem sites and several tributary sites. Mean column velocity was measured at 20 verticals or more at each cross-section. When streamflow was compared between years with only visual approximations to those in 1998-2001 with the flowmeter measurements, comparisons should be thought of as more qualitative than quantitative, and as only approximate.

RESULTS

General Habitat Trends in the Mainstem

Habitat quality generally improved from 2000 to 2001 at sampling sites with regard to more escape cover in most habitat types of each sampling site and reduced embeddedness. The increased cover was due primarily to increased growth of overhanging willows and *Carex spp*., with some due to reduced embeddedness of larger boulders. However, habitat depth and water velocity were reduced, as well as whitewater cover in the Gorge due to reduced streamflow in 2001. Percent sand in fastwater habitat generally remained the same or increased, particularly in the lower River, despite the reduced embeddedness of larger cobbles and boulders.

Proportion of Habitat Types and Habitat Characteristics

Habitat typing was not performed in 2001. However, for background, the results of survey work and habitat-typing for 1999 and 2000 are summarized for each mainstem reach in Tables 3-17. Results of this work are described in the previous year's monitoring report (Alley 2001).

Table 3. Mainstem San Lorenzo River in Reach 0a; Summary of Habitat Types and Habitat Characteristics for 1999 and 2000, Located Between Water Street Bridge and the Highway 1 Bridge.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth ft		% of Surveyed Portion	
	2000	'99	2000	'99	2000	'99	2000	'99	2000	'99	2000	'99	2000	'99
MCP	1	0	140	0	140	0	44	0	1.7	0	3.0	0	3.3	0
LSR	9	1	1066	96	118	96	27	15	1.4	1.0	2.2	2.0	24.9	2.2
LSL	0	3	0	509	0	169	0	38	0	1.4	0	3.1	0	11.6
RUN	12	13	1352	2889	113	222	19	19	1.2	0.9	1.9	1.5	31.6	65.6
GLD	14	1	1326	205	95	205	33	35	0.9	0.6	1.3	1.1	31.0	4.7
LGR	7	10	391	703	56	170	20	20	0.6	0.4	0.9	0.9	9.2	16.0

Total Units Surveyed- 43/ 28; Total Length Surveyed- 4,275 ft./ 4,402 ft.

mid-channel pool (MCP), lateral scour rootwad pool (LSR), lateral scour woody debris pool (LSL), glide (GLD), low gradient riffle (LGR).

Table 4. Mainstem San Lorenzo River in Reach 0b; Summary of Habitat Types and Habitat Characteristics for 1999 and 2000, Located Between Highway 1 and the Tait Street Diversion.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth ft		% of Surveyed Portion	
	2000	'99	2000	'99	2000	'99	2000	'99	2000	'99	2000	'99	2000	'99
DPL	1	1	51	193	51	193	74	63	2.1	1.3	5.0	5.4	1.7	5.7
LSR	1	1	194	493	194	493	26	40	1.6	1.4	2.6	2.5	6.6	14.5
LSL	0	1	0	587	0	587	0	40	0	1.4	0	4.0	0	17.3
RUN	5	4	594	1500	119	375	18	31	1.0	0.6	1.5	1.5	20.3	44.1
GLD	10	2	1897	471	190	209	35	35	0.65	0.55	1.2	1.3	64.9	13.8
LGR	3	3	188	158	63	53	21	22	0.4	0.35	0.9	0.7	6.4	4.6

Total Units Surveyed- 20/ 12; Total Length Surveyed- 2,924 ft./ 3,402 ft.

dammed pool (DPL), lateral scour rootwad pool (LSR), lateral scour woody debris pool (LSL), glide (GLD), low gradient riffle (LGR).

Table 5. Mainstem San Lorenzo River in Reach 1; Summary of Habitat Types and Habitat Characteristics, 1999 and 2000, Located in the Vicinity of Paradise Park.

Habitat Type	Units Measured # 1999	Units Measured # '00	Total Length ft 1999	Total Length ft '00	Average Length ft 1999	Average Length ft '00	Average Width ft 1999	Average Width ft '00	Average Depth ft 1999	Average Depth ft '00	Average Maximum Depth ft 1999	Average Maximum Depth ft '00	% of Surveyed Portion 1999	% of Surveyed Portion '00
LSR	1	1	100	118	100	118	22	25	1.9	1.3	2.9	2.3	12.6	3.2
LSBk	2	3	341	420	171	140	23	29	3.0	2.4	5.6	4.8	9.6	11.5
LSBo	1	3	109	585	109	195	57	41	2.1	1.5	3.2	2.7	3.1	16.0
CRP	1	1	336	188	336	188	45	43	2.1	2.0	3.1	3.0	9.5	5.1
Run&GLD	13	9	1337	1571	103	175	59	38	1.3	1.2	1.8	1.8	37.7	42.9
LGR	11	9	874	776	79	86	21	28	0.9	0.9	1.4	1.4	24.7	21.2

Total Units Surveyed- 30/ 26; Total Length Surveyed- 3,542/ 3,658 ft.
lateral scour rootwad pool (LSR), lateral scour bedrock pool (LSBk), lateral scour boulder pool (LSBo), corner pool (CRP), glide (GLD), low gradient riffle (LGR).

Table 6a. Mainstem San Lorenzo River in Reach 2a; Summary of Habitat Types and Habitat Characteristics, 1999 and 2000, Located in Lower San Lorenzo River Gorge Along the Rincon Trail.

Habitat Type	Units Measured # 1999	Units Measured # '00	Total Length ft 1999	Total Length ft '00	Average Length ft 1999	Average Length ft '00	Average Width ft 1999	Average Width ft '00	Average Depth ft 1999	Average Depth ft '00	Average Maximum Depth ft 1999	Average Maximum Depth ft '00	% of Surveyed Portion 1999	% of Surveyed Portion '00
MCP	1	0	235	0	235	0	40	0	2.8	0	4.0	0	6.8	0
LSBk	4	5	1307	1373	327	275	53	60	2.9	3.5	6.0	6.6	37.7	40.6
LSBo	1	4	120	532	120	140	45	42	3.0	2.6	5.0	4.0	3.4	15.7
LSL	1	1	82	41	82	41	25	28	2.2	2.3	3.5	3.4	2.4	1.2
Run&GLD	9	9	786	509	87	57	37	38	2.0	1.7	3.1	2.4	22.6	15.0
LGR	5	7	836	845	167	121	41	39	1.3	1.2	2.0	2.0	24.1	25.0
HGR	2	2	105	86	53	43	40	23.5	1.0	1.15	1.8	2.1	3.0	2.5

Total Units Surveyed- 23/ 28; Total Length Surveyed- 3,471/ 3,386 ft.

mid-channel pool (MCP), lateral scour bedrock pool (LSBk), lateral scour boulder pool (LSBo), lateral scour woody debris pool (LSL), glide (GLD), low gradient riffle (LGR), high gradient riffle (HGR).

Table 6b. Side Channel of the San Lorenzo River in Reach 2b; Summary of Habitat Types and Habitat Characteristics, 2000, Located in Lower San Lorenzo River Gorge Along the Rincon Trail.

Habitat Type	Units Measured # 2000	Total Length ft 2000	Average Length ft 2000	Average Width ft 2000	Average Depth ft 2000	Average Maximum Depth ft 2000	% of Surveyed Portion 2000
LSL	4	212	53	25	1.7	2.8	15.7
RUN	6	569	95	30	1.3	1.8	42.2
SRN	1	271	271	18	0.8	1.9	20.1
LGR	7	295	42	17			21.9

Total Units Surveyed- 18; Total Length Surveyed- 1,347 ft.

lateral scour woody debris pool (LSL), step-run (SRN), low gradient riffle (LGR).

Table 7. Mainstem San Lorenzo River in Reach 3; Summary of Habitat Types and Characteristics in 1999 and 2000, Located in Upper San Lorenzo River Gorge, Downstream of Eagle Creek.

Habitat Type	Units Measured # 1999	'00	Total Length ft 1999	'00	Average Length ft 1999	'00	Average Width ft 1999	'00	Average Depth ft 1999	'00	Average Maximum Depth ft 1999	'00	% of Surveyed Portion 1999	'00
LSBK	17	16	2012	2287	118	143	29	37	3.2	3.2	5.6	5.3+	49.5	58.0
LSBo	0	1	0	53	0	53	0	48	0	2.0	0	3.5	0	1.3
RUN	11	7	1020	715	93	102	30	41	2.1	2.1	3.4	3.1	25.1	18.2
SRN	0	1	0	149	0	149	0	38	0	2.0	0	2.8	0	3.8
LGR	14	11	1030	884	74	80	27	29	1.7	1.9	2.7	2.6	25.4	22.5

Total Units Surveyed- 42/ 36; Total Length Surveyed- 4,062/ 3,936 ft.

lateral scour bedrock pool (LSBk), lateral scour boulder pool (LSBo), step-run (SRN), low gradient riffle (LGR).

Table 8. Mainstem San Lorenzo River in Reach 4; Summary of Habitat Types and Characteristics in 1999 and 2000, Located in Upper Henry Cowell Park and Downstream of the Felton Diversion Dam.

Habitat Type	Units Measured # 1999	'00	Total Length ft 1999	'00	Average Length ft 1999	'00	Average Width ft 1999	'00	Average Depth ft 1999	'00	Average Maximum Depth ft 1999	'00	% of Surveyed Portion 1999	'00
LSBo	0	2	0	564	0	282	0	45	0	2.05	0	4.0	0	15.7
DPL	0	1	0	40	0	40	0	44	0	1.7	0	2.0	0	1.1
LSR	2	0	422	0	211	0	40	0	2.6	0	5.0	0	10.1	0
LSL	3	3	1102	484	367	161	42	51	2.4	2.1	3.9	3.4	26.4	13.5
CRP	1	1	304	330	304	330	55	40	1.5	2.9	4.2	4.0	7.3	9.2
LSBk	1	1	128	136	128	136	70	47	2.5	2.5	4.0	6.0	3.1	3.8
RUN	9	8	1532	862	170	108	39	36	1.5	1.5	2.4	2.3	36.7	24.0
GLD	0	8	0	637	0	80	0	49	0	1.2	0	1.8	0	17.7
LGR	7	9	689	543	98	60	30	39	0.7	0.8	1.2	1.4	16.5	15.1

Total Units Surveyed- 23/ 33; Total Length Surveyed- 4,177/ 3,596 ft.

lateral scour boulder pool (LSBo), dammed pool (DPL), lateral scour rootwad pool (LSR), lateral scour woody debris pool (LSL), corner pool (CRP), lateral scour bedrock pool (LSBk), , glide (GLD), low gradient riffle (LGR).

Table 9. Mainstem San Lorenzo River in Reach 5; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, Located Between the Zayante Creek Confluence and Felton Dam.

Habitat Type	Units Measured # 1999	'00	Total Length ft 1999	'00	Average Length ft 1999	'00	Average Width ft 1999	'00	Average Depth ft 1999	'00	Average Maximum Depth ft 1999	'00	% of Surveyed Portion 1999	'00
DPL	1	1	186	163	165	163	80	58	1.0	1.5	2.9	3.7	9.9	8.2
LSL	2	1	205	44	103	44	35	28	1.8	2.3	3.6	3.2	10.9	2.2
LSBk	1	1	89	289	89	289	45	45	2.2	1.1	4.0	4.2	4.7	14.6
LSR	1	1	75	40	75	40	16	29	1.7	1.8	2.9	2.1	4.0	2.0
RUN	6	3	1243	303	207	101	32	25	1.1	1.1	2.4	1.8	66.0	15.3

GLD	0	10	0	1024	0	102	0	35.5	0	1.0	0	1.7	0	51.7
LGR	2	3	84	117	42	39	22	18	0.8	0.8	1.2	1.3	4.5	5.9

Total Units Surveyed- 11/ 20; Total Length Surveyed- 1,978/ 1,980 ft.

Table 10. Mainstem San Lorenzo River in Reach 6; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, Located Between Zayante and Newell Creek Confluences.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth ft		% of Surveyed Portion	
	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00
LSBk	3	8	1353	2391	451	298	27	38	2.6	2.3	4.4	4.1	28.6	46.8
DPL	2	3	349	259	179	130	28	22	1.7	1.3	2.4	2.2	7.4	5.1
LSL	4	1	428	115	107	115	24	40	2.1	1.2	3.6	2.0	9.0	2.2
LSR	1	0	234	0	234	0	23	0	2.4	0	5.0	0	4.9	0
LSBo(art.)	0	1	0	52	0	52	0	50	0	1.8	0	2.8	0	1.0
GLD	0	3	0	218	0	73	0	31	0	1.4	0	1.6	0	4.3
RUN	11	14	1722	1217	157	87	24	26	1.3	1.1	2.1	1.9	36.4	23.8
LGR	8	7	645	860	81	72	15	21	0.7	0.8	1.0	1.2	13.6	16.8

Total Units Surveyed- 29/ 37; Total Length Surveyed- 4,731/ 5,112 ft.

Table 11. Mainstem San Lorenzo River in Reach 7; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, Located Between Newell Creek Confluence and the Bend Above Ben Lomond.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth ft		% of Surveyed Portion	
	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00
LSBk	8	9	1354	1500	169	188	31	40	2.4	2.2	2.7	3.9	37.8	38.2
MCP	2	3	1213	1332	607	444	58	46	1.7	1.7	3.6	3.1	33.9	33.9
CRP	1	1	300	250	300	250	55	70	3.7	4.0	7.0	6.0	8.4	6.4
RUN	3	4	230	199	77	50	22	20	0.7	1.0	1.1	1.5	6.4	5.1
GLD	0	3	0	154	0	51	0	26	0	0.7	0	0.9	0	3.9
LGR	7	10	485	496	69	50	18	20	0.8	0.7	1.4	1.1	13.5	12.6

Total Units Surveyed- 21/ 30; Total Length Surveyed- 3,582/ 3,931 ft.

lateral scour bedrock pool (LSBk), mid-channel pool (MCP), corner pool (CRP), glide (GLD), low gradient riffle (LGR).

Table 12. Mainstem San Lorenzo River in Reach 8; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, Located Between the Bend Above Ben Lomond and the Clear Creek Confluence in Brookdale.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth ft		% of Surveyed Portion	
	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00
LSBk	9	8	2506	2468	330	309	36	46	2.8	2.9	5.0	5.6	62.1	59.7
DPL-LSBk	1	1	796	755	796	755	35	52	2.4	2.5	5.0	5.5	19.7	18.3
LSBo	0	1	0	68	0	68	0	12	0	2.6	0	3.3	0	1.6
RUN	3	5	219	206	73	41	24	19	1.4	1.4	2.1	2.1	5.4	5.0
HGR-LGR	9	10	516	639	57	64	19	18	0.9	0.9	1.2	1.4	12.8	15.4

Total Units Surveyed- 22/ 25; Total Length Surveyed- 4,037/ 4,136 ft.

lateral scour bedrock pool (LSBk), dammed lateral scour bedrock pool (DPL-LSBk), lateral scour boulder pool (LSBo), high gradient riffle (HGR), low gradient riffle (LGR).

Table 13. Mainstem San Lorenzo River in Reach 9; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, Located Between the Clear Creek and Boulder Creek Confluences.

Habitat Type	Units Measured # 1999	Units Measured # '00	Total Length ft 1999	Total Length ft '00	Average Length ft 1999	Average Length ft '00	Average Width ft 1999	Average Width ft '00	Average Depth ft 1999	Average Depth ft '00	Average Maximum Depth ft 1999	Average Maximum Depth ft '00	% of Surveyed Portion 1999	% of Surveyed Portion '00
LSBk	5	9	1847	1913	369	377	31	43	2.6	2.1	4.7	3.8	66.6	64.7
LSBo	2	1	126	117	63	117	23	32	1.0	0.9	1.6	1.4	4.5	4.0
LSL	1	0	45	0	45	0	25	0	0.9	0	1.6	0	1.6	0
RUN	4	5	354	395	89	79	18	24	1.0	1.0	1.7	1.6	12.8	13.4
GLD	0	1	0	108	0	108	0	32	0	0.9	0	1.4	0	3.7
HGR-LGR	8	8	400	422	50	52	19	21.5	0.7	0.7	1.1	1.1	14.4	14.3

Total Units Surveyed- 18/ 24; Total Length Surveyed- 2,772/ 2,955 ft.

Table 14. Mainstem San Lorenzo River in Reach 10; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, Located Between the Boulder Creek and Kings Creek Confluences.

Habitat Type	Units Measured # 1999	Units Measured # '00	Total Length ft 1999	Total Length ft '00	Average Length ft 1999	Average Length ft '00	Average Width ft 1999	Average Width ft '00	Average Depth ft 1999	Average Depth ft '00	Average Maximum Depth ft 1999	Average Maximum Depth ft '00	% of Surveyed Portion 1999	% of Surveyed Portion '00
LSBk	10	15	2245	2992	225	199	21	22	1.4	1.4	3.3	2.9	75.1	70.2
CRP	0	1	0	82	0	82	0	25	0	1.3	0	2.8	0	1.9
LSR	1	2	55	134	55	67	13	18	0.4	0.7	0.7	1.4	1.8	3.1
LSBo	1	0	61	0	61	0	25	0	1.3	0	2.1	0	2.0	0
RUN	4	6	194	351	49	59	14	17	0.8	0.8	1.4	1.2	6.5	8.2
GLD	0	3	0	189	0	63	0	16	0	0.7	0	1.1	0	4.4
LGR	12	12	434	515	36	43	18	14.5	0.5	0.4	0.9	0.6	14.5	12.1

Total Units Surveyed- 28/ 36; Total Length Surveyed- 2,989/ 4,263 ft.

Table 15. Mainstem San Lorenzo River in Reach 11; Summary of Habitat Types and Characteristics in 1999 and 2000, Located Between the Kings Creek Confluence and a Point of Increased Gradient Above Riverside Grove.

Habitat Type	Units Measured # 1999	Units Measured # '00	Total Length ft 1999	Total Length ft '00	Average Length ft 1999	Average Length ft '00	Average Width ft 1999	Average Width ft '00	Average Depth ft 1999	Average Depth ft '00	Average Maximum Depth ft 1999	Average Maximum Depth ft '00	% of Surveyed Portion 1999	% of Surveyed Portion '00
LSBk	15	15	1508	1514	101	101	14	16	1.0	1.1	1.8	2.0	43.8	45.8
CRP	2	2	251	158	47	79	15	15.5	1.0	1.3	2.2	2.45	7.3	4.8
LSBo	1	0	34	0	34	0	19	0	0.8	0	1.2	0	1.0	0
DPL		1	0	46	0	46	0	15	0	1.0	0	1.9	0	1.4
LSR	0	1	0	44	0	44	0	15	0	1.4	0	2.1	0	1.3
LSL	1	0	36	0	36	0	10	0	1.0	0	1.8	0	1.0	0
RUN	13	12	966	867	74	72	13	14	0.5	0.5	1.0	1.0	28.1	26.2
GLD	0	3	0	81	0	27	0	17	0	0.5	0	1.1	0	2.5
LGR	16	16	642	594	40	37	10	14	0.4	0.4	0.7	0.6	18.7	18.0

Total Units Surveyed- 48/ 50; Total Length Surveyed- 3,437/ 3,304 ft.

Table 16a. Mainstem San Lorenzo River in Lower Reach 12a; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From Above Riverside Grove to the Highway 9 Overpass at Waterman Gap.

Habitat Type	Units Measured # 1999	'00	Total Length ft 1999	'00	Average Length ft 1999	'00	Average Width ft 1999	'00	Average Depth ft 1999	'00	Average Maximum Depth ft 1999	'00	% of Surveyed Portion 1999	'00
LSBk	18	26	1034	1218	57	47	13	14.5	1.3	1.3	1.9	2.0	41.0	42.3
LSBo	5	6	170	173	34	29	12	13	1.2	1.3	1.9	1.9	6.7	6.0
LSR	3	0	199	0	66	0	15	0	0.6	0	1.1	0	7.9	0
LSL	0	5	0	210	0	42	0	18	0	2.1	0	2.8	0	7.3
CRP	1	1	47	113	47	113	15	10	0.8	1.2	1.5	2.3	1.9	3.9
DPL(art.)	0	1	0	12	0	12	0	9	0	1.3	0	1.8	0	0.4
RUN	5	10	240	306	48	31	14	14	0.6	0.6	1.2	0.9	9.5	10.6
SRN	9	10	318	292	35	29	9	12.5	1.0	0.8	1.6	1.4	12.6	10.1
GLD	0	2	0	50	0	25	0	9.5	0	0.35	0	0.5	0	1.7
LGR	19	24	515	503	27	21	10	10	0.4	0.4	0.8	0.7	20.4	17.5

Total Units Surveyed- 60/ 85; Total Length Surveyed- 2,523/ 2,877 ft.

Table 16b. Mainstem San Lorenzo River in Upper Reach 12b; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From the Highway 9 Overpass at Waterman Gap to the Gradient Change Further Upstream.

Habitat Type	Units Measured # 1999	'00	Total Length ft 1999	'00	Average Length ft 1999	'00	Average Width ft 1999	'00	Average Depth ft 1999	'00	Average Maximum Depth ft 1999	'00	% of Surveyed Portion 1999	'00
LSBk	6	3	524	233	87	78	13	15	1.4	1.9	3.3	2.5	26.5	11.8
LSBo	4	5	161	187	40	37	13	13	1.4	1.2	2.0	1.9	8.2	9.4
LSR	2	5	67	244	34	50	13	11	1.5	1.2	2.4	2.0	3.4	12.3
LSL(art.)	3	6	176	190	57	32	15	14	1.3	1.3	1.9	1.7	8.9	9.6
LSL	1	2	83	100	83	50	15	10	1.8	1.2	2.6	1.2	4.2	5.0
CRP-LSBk	1	1	72	79	72	79	14	14	2.6	2.8	5.0	4.2	3.6	4.0
DPL	1	2	38	134	38	67	13	14	1.0	1.05	1.4	1.55	1.9	6.8
RUN	6	8	192	253	32	32	11	11	0.8	0.6	1.3	1.1	9.7	12.8
SRN	5	3	249	151	50	50	10	12	0.8	0.7	1.3	1.0	12.6	7.6
GLD	0	1	0	15	0	15	0	17	0	0.5	0	1.0	0	0.8
LGR-HGR	15	13	412	393	28	30	12	11	0.7	0.5	1.0	0.9	20.9	19.9

Total Units Surveyed- 44/ 53;
Total Length Surveyed- 1,974/ 1,979 ft.

lateral scour bedrock pool (LSBk), lateral scour boulder pool (LSBo), lateral scour rootwad pool (LSR), lateral scour woody debris pool (LSL), corner pool (CRP), dammed pool (DPL), step-run (SRN), glide (GLD), low gradient riffle (LGR), high gradient riffle (HGR).

Bank-full stream channels widen when excessive sediment must be transported, leading to more streambank erosion and potential channel braiding. Channel widening and streambank erosion had been substantial in Reach 4 in 1998, washing old-growth sycamores into the channel, downstream of the Henry Cowell Bridge in Felton. The island in Reach 4 that developed in 1998 remained in 2001. In

2000, the critical passage riffle at the upper end of Reach 2 was especially wide and had become divided into two channels with different gradients. The main, southern portion of this critical passage riffle was relatively lower gradient with a 7-foot, transverse cascade at its tail and averaged 36 feet in width. The northern portion had a steeper, consistent gradient throughout in a step-run fashion and averaged 20 feet in width in early August. This would be the side (northern) that adults would pass through the riffle, but most water would be passing through the other (southern) side. Reach 2 had a quarter-mile secondary channel in 2000 and 2001 that cut across a sharp bend area at the lower end of the habitat-typed segment, with significant streambank erosion and numerous redwoods laying in and across the channel. The large sycamores that had been cutting a pool where they fell in upper Reach 4 in 1999 were gone in 2000, reportedly being washed away during winter stormflows (**G. Gray, personal comm**.). A smaller sycamore remained in the channel in 2001, parallel to the flow at the lower end of the habitat-typed segment of Reach 4.

Table 17. Positive and Negative Habitat Changes from 2000 to 2001 at Sampling Sites in the San Lorenzo River Mainstem. (Refer to footnotes for symbol explanation.)

Habitat Parameter	Lower River R-1	R-2	R-3	R-4	R-5	Middle River R-6	R-7	R-8	R-9	Upper River R-10	R-11	R-12
Riffle Escape Cover	+++	+++		+++	+++	+++	+++	+++	+++	---	---	+++
Run Escape Cover	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	---
Pool Escape Cover	+++									+++	+++	+++
Mean Riffle Depth	---	---	---	---	---	---	---	---	---	---	---	+++
Mean Run/Step-run Depth		---	+++	---	+++		---	---	---	+++		---
% Sand-Riffles	---	---	---	---	+++							
% Sand-Stp-rn/ run		---		---		---	+++			+++	---	
Embeddedness- Riffle/runs	+++		+++	+++	+++	+++	+++	+++		+++	+++	+++

+++ denotes habitat condition improved.
--- denotes habitat condition worsened.
Blank space denotes similar or same values except for Pool Escape Cover, for which no data were collected in 2001.

Substrate Composition and Embeddedness- Mainstem

Lower River. In the lower River (Reaches 0-5), percent fines in riffles ranged between 30 and 40% in sites in Reaches 1-5 and reached 95% in Reach 0b. In riffles percent fines increased in Reaches 1-4, 10-20% at sampling sites in 2001, while it declined 35% at the sampling sites in Reach 5 and remained unchanged at the sampling site in Reach 0b (**Table 18**). In runs, percent fines increased substantially at sites in Reaches 2 (30%) and 4 (40%). Other sites changes 5% or less. Despite the increase in percent fines in riffles and some runs in the lower River, embeddedness for riffle and run habitat decreased at 4 of 5 sites and remained unchanged at Site 2 (Reach 2) (**Figure 23**).

Middle River. In the middle River (Reaches 6-9) in 2001, fine sediment in riffles decreased 5% in sites of Reaches 6 and 7, but continued to increase 5% in Reaches 8 and 9 as it had increased 10% from 1999 to 2000 (**Table 18**). Fine sediment continued to increased in run habitat sampled in Reach 6, but declined substantially (15%) at the site in Reach 7. It remained the same at the site in Reach 8 while it declined slightly (5%) at the site in Reach 9. The reduced fine material at Site 7 may have resulted in the slow draining of the Ben Lomond pool in 2001 instead of the rapid release in previous years that may have moved fine material downstream from behind the impoundment or from pools into runs and riffles below the impoundment. Regarding embeddedness, as in the lower River, embeddedness in fastwater habitat declined in most sites (3 of 4 sites) in 2001, with it remaining the same at Site 9 in Reach 9.

Upper River. In the upper River (Reaches 9-12) in 2001, the big changes in fine sediment occurred in sampled pools of Reach 11 (reduction of 20%) and sampled runs of Reach 10 (declined 40%), Reach 11 (increased 20% despite reduction in pools) and Reach 12 (declined 15% despite 10% increase in pools) (**Table 18**). However, these big changes were just in the sampled habitats and may not hold for entire reaches. Regarding embeddedness, the upper River followed the overall trend of the mainstem with reduced embeddedness in sampled riffles and runs of all three reaches. Embeddedness in pools declined likewise.

Escape Cover- Mainstem

Lower River. An important habitat parameter affecting juvenile survival was escape cover, particularly in fastwater habitat. Escape cover per foot of riffle was determined in each mainstem sampling site. Downstream of the Zayante Creek confluence (lower San Lorenzo), riffle cover increased over 2000 levels in 4 of 5 mainstem sites where riffles were sampled, with it declining only in Reach 3 in the Gorge (**Figure 25b**). The increase was due to increased overhanging willows, primarily with some willow and box elder. In Reach 3 the escape cover under unembedded boulders increased in the 2001 riffle due to the reduced embeddedness, but cover from whitewater turbulence was less due to the reduced streamflow in 2001. Escape cover increased in runs in all 6 reaches due to the overhanging vegetation, for the most part (**Figure 26**). In Reach 3 in the Gorge, there was reduced embeddedness and more cover under boulders in 2001. Reduced embeddedness in 4 out of 5 riffle sites aided in increased escape cover (**Figure 23**).

Middle River. Escape cover improvement in the middle River paralleled changes in the lower River. It increased in both riffles and runs at all sites due to increased overhang of willows and greater development of *Carex spp*. sedges in 2001 (**Figures 25b and 26**). Reduced embeddedness at sites in Reaches 7 and 8 aided in increased escape cover (**Figure 23**).

Upper River. In the upper River as in tributaries, pools become the primary habitat for juvenile steelhead, particularly yearling-sized ones. Escape cover increased in pools of all 3 reaches in 2001 (**Figure 25a**). In Reach 12 (Sites 12a and 12b) boulders in pools may provide cover if less embedded. Embeddedness declined slightly there in 2001 (**Figure 24**).

Fall Streamflow- Mainstem

Compared to 2000, fall baseflow was less in 2001 downstream of the Boulder Creek confluence in the San Lorenzo River (**Table 19; Figure 35**) for the third year in a row since the El Niño year, 1998. Upstream of Boulder Creek, fall baseflow was 50% of 2000 levels or less (**Figure 36**). At Site 1 in Paradise Park, streamflow was 19.6 cfs in 2001, which was 90% of that measured in 2000 and 57% of the 34.3 cfs in 1998. At Site 2 in the Rincon area, streamflow was 17.2 cfs in 2001, which was 82% of that measured in 2000. At Site 4 below Gold Gulch in upper Henry Cowell Park, streamflow was 15.5 cfs in 2001, which was 71% of that measured in 2000and 47% of the 32.7 cfs measured in 1998. At Site 6 below the Fall Creek confluence, streamflow in 2001 was 9.4 cfs, which was 81% of that measured in 2000 and 40% of the 23.4 cfs in 1998. Streamflow at Site 7 in Ben Lomond was 3.7 cfs. At Site 8 in Brookdale below the Clear Creek confluence, streamflow was 3.1 cfs, which was 74% of that measured in 2000 and 30% of the 10.3 cfs in 1998. Streamflow at Site 9 below Boulder Creek confluence was 3.0 cfs in 2001.

In the upper River above the Boulder and Bear creek confluences at Site 10 on the San Lorenzo River, measured streamflow in 2001 was 0.6 cfs. This was 46% of the 1.3 cfs measured in 2000 and 20% of the 3 cfs in 1998. At Site 11 below the Teihl Road Bridge, streamflow in 2001 was 0.4 cfs, which was 50% of what it was in 1999 and 2000 and 24% of the 1.7 cfs measured in 1998.

Water Depth- Mainstem

Lower River. Average mean riffle depth by sampling site declined 0.1-0.2 feet in all reaches except Reach 5, where depth declined 0.3 feet (**Figure 27**). These declines were substantial except in Reach 3 where mean depth was 2 feet and were consistent with reduced streamflow. However, juvenile densities increased at 6 of 7 sites in the lower River despite this shallowing (**Table 43**). Changes in run depths were more variable than in riffles due to differences in scour. At sites in Reaches 0b and 1, mean depth remained unchanged in runs (**Figure 28**). Depths declined 0.2 feet in runs at sites in Reaches 2 and 4, consistent with less streamflow in 2001. However, depths increased in runs at sites in Reaches 3 and 5 by 0.2 feet in 2001.

Middle River. In the middle River, average mean depth in riffles at sampling sites declined in all Reaches in 2001 and most substantially in Reach 6 (**Figure 27**). Regarding run habitat at sampling sites, average mean depth declined in all reaches except Reach 6 where it remained constant in 2001 (**Figure 28**). The declines in depth were substantial in reducing habitat for smolt-sized fish at Site 9 but not other sites (**Table 43**). Because of the higher production of YOY's in 2001, fish densities were higher at all middle River sampling sites compared to 2000.

Upper River. In the upper River in 2001, average mean pool depth and averaged maximum pool depth decreased at all sampling sites except Site 12a where slight scour was evident through the canyon below Waterman Gap (**Figure 29**). Densities of smolt-sized fish increased at Sites 12 a and 12 b while it decreased at Sites 10 and 11 (**Table 43**). Depths in riffles showed a similar pattern (**Figure 27**), but for runs depth increased at Site 10, remained constant at Site 11 and declined at Sites 12a and 12b (**Figure 28**). The reduced pool depths at Sites 11 and 12b and the reduced run depths at sites 12a and 12b reduced the quality of yearling habitat.

Table 18. Streambed Sedimentation Expressed as Percent Fine Sediment by Habitat Type in Mainstem Reach Segments, 1997-2000 and at Sampling Sites in 2000 and 2001.

Habitat Type
(Percent Sand and Silt- Visually Estimated)

Reach	Pool					Riffle					Run/Step-run				
#	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001
0			90	95/90*	90	-**	-	25	75/95	95	-	-	90	85/98	95
1	75	80	80	80	-	10	25	20	20/15	30	35	55	40	55/55	50
2	70	75	75	70	-	10	30	30	25/15	35	20	40	45	50/35	65
3	70	75	85	80	-	35	45	35	40/30	40	70	60	55	60/65	65
4	35	70	85	70	-	5	30	25	30/10	30	25	65	65	50/30	70
5	-	100	90	95	-	-	-	25	35/60	35	-	75	75	70/99	95
6	70	80	70	80	-	10	25	40	35/40	35	35	50	55	60/60	75
7	45	70	65	70	-	5	25	20	25/30	25	5	30	40	45/50	35
8	30	70	70	75	-	0	20	20	30/25	30	10	35	40	45/50	50
9	55	80	60	70	-	10	15	20	30/35	35	20	35	35	45/45	40
10	35	85	75	75/60	60	1	20	20	25/30	25	20	60	50	45/60	40
11	30	75	65	65/65	45	2	25	20	20/25	20	20	35	35	30/30	50
12	40	60	55	55/40	50	5	15	15	25/30	30	15	35	30	35/40	25

*** Number after the slash is the percent sand at the sampling site in 2000.**
**** Indicates no data.**

Table 19. Streamflow Measured by Flowmeter at Sampling Sites, 1995-2001.

Site #- Location	1995	1996	1997	1998	1999	2000	2001
1- Paradise Park	22.9	25.5		34.3	26.2	21.7	19.6
2- Rincon					24.0	21.1	17.2
3- SLR Gorge	23.3	20.5					
4- Upper Henry Cowell	18.7			32.7	23.3	21.8	15.5
5- Below Zayante Cr. Confluence				31.9			
6- Below Fall Cr. Confluence	14.6			23.4	12.8	11.6	9.4
7- Ben Lomond	5.8					5.4	3.7
8- Below Clear Cr.	4.2			10.3	4.9	4.2	3.1
9- Below Boulder Cr. Confluence	4.6			7.2	3.5		3.0
10- Below Kings Cr.				3.0	1.1	1.3	0.6
11- Teihl Road				1.7	0.8	0.8	0.4
12a- Lower Waterman Gap				1.0	0.7		
13a- Zayante below Bean Cr.				8.5	6.3	5.2	4.7
13b- Zayante above Bean Cr.				3.9	2.9	2.8	1.9
14b- Bean below Lockhart Gulch	1.5			1.1	1.1	1.0	1.1
15- Fall Creek	2.0			3.4	2.2	1.7	1.7
16- Newell Cr.	1.6					0.51	
17a- Boulder Cr.	2.0			2.2		1.1	1.0
18a- Bear Cr.					0.45	0.61	0.34
19a- Lower Kings Creek				1.1	0.11	0.17	0.02
20a- Lower Carbonara Cr.	0.33	0.36					
21a- Branciforte below Granite Creek.				0.80			

Proportion of Habitat Types and Habitat Characteristics- Tributaries in 2000

Habitat typing was not performed in 2001, but were assumed to be roughly unchanged from 2000 proportions in developing juvenile population estimates. Results of previous habitat typing are included here as background. Tributary reaches were habitat-typed for the first time in 1998, and it was repeated in 1999 and 2000. Within each tributary sub-basin, stream gradient, levels of winter stormflow and sediment load affected habitat proportions and characteristics. Based on habitat-typed segments, most tributary reaches (16 of 20 in 1998 and 1999 and 15 of 20 in 2000) had a high proportion of pool habitat between 50 and 80 percent of the habitat length (**Tables 20-40**). Pool habitat had the highest density of juvenile steelhead in tributaries, followed by step-runs that appeared in upper reaches. In 2000, reaches with less than 50 percent pool habitat were lower Bean (14a), middle Bean (14b), Fall (15), lower Boulder (17a) and upper Carbonera (20b) creeks. **Tables 1a-c of reach and site descriptions are repeated on pages 131-134 before the Figures.** Overall, the trend in tributaries was for increased pool habitat in 2000 compared to 1999, with 12 habitat-typed segments out of 21 increasing in pool habitat.

The loss of step-run to run and riffle habitat in upper Zayante Creek in 2000 compare to 1999 may have resulted from reduced baseflow as was measured in lower reaches (**Table 19; Figure 35**). Fall Creek had the lowest proportion of pools and the highest proportion of riffles as in previous years. Productive step- runs were common in the range of 22-31% in upper reaches of Zayante (13d), throughout Boulder (17a-c), Bear (18b), Kings (19b), Carbonera (20b) and Branciforte (21b). Run habitat was most abundant at the 23-27% level in lower Bean (14a), upper Bean (14c) and upper Carbonera (20b). Fall Creek had the lowest proportion of pools and the highest as riffles (67% as reported). This was down from 1998, however, when riffle habitat was 75% under higher baseflow conditions.

Changes in Habitat Conditions- General Trends in Tributaries from 2000 to 2001

Refer to the summary **Table 41** for habitat trends at sampling sites. Of the nine major tributaries, habitat conditions improved (more escape cover and greater depth) in pools of upper Branciforte, upper Boulder, upper Kings, sites A and C in Zayante Creek and all sites of Bean Creek. Pools generally shallowed except those previously mentioned in Zayante, Bean, Boulder and Kings creeks. Fastwater habitat generally shallowed due to reduced streamflow in 2001, but substrate conditions improved (less sand and embeddedness) in upper Boulder and Newell creeks in fastwater habitat. Generally, pools and runs became more sandy and riffles less. Embeddedness generally increased in riffles and runs.

Substrate Composition- Tributaries

Sand and silt were the dominant substrate in tributary pools, with only 5 of 20 sites showing improvement with less fine sediment in 2001 (**Tables 41 and 42**). These were lower and middle Bean, lower Bear, upper Carbonera and Fall creeks. But only in Bean Creek did fastwater habitat also improve. However, percent fines in pools were consistently 60% or greater in all tributary sites except for Newell, Boulder and Bear creeks. Riffles of Branciforte, Zayante Newell, Boulder creeks showed the most improvement with less sand (**Tables 41 and 42**). However, pools were more sandy in these creeks.

Escape Cover-Tributaries

Escape cover in tributary pools increased at all sites in Zayante and Bean creeks. This was caused by more woody debris in the form of fallen trees at Site B in Zayante and Sites A and B in Bean Creek, combined with reduced pool embeddedness at other sites (**Figures 30b and 31**). A heavy snowstorm the previous winter was responsible for many trees falling. Considerably more pool cover was measured at the two upper sites in Boulder Creek and upper sites on Kings, Carbonera and Branciforte creeks. All of these sites had less pool embeddedness except upper Kings. The overall average pool cover increased for tributaries in 2001 (**Table 41**).

Fall Streamflow- Tributaries

Streamflow declined in 4 of 6 tributaries that were measured in fall of 2001. The exceptions were an increase in streamflow in middle Bean Creek of 0.1 cfs and the same streamflow in Fall Creek as the previous year (**Table 19; Figures 35 and 36**). However, upstream in Bean Creek above the Mackenzie Creek confluence, the channel was dry at the former 14c Sampling Site in 2000. The most significant declines were in Kings (decline to only 0.02 cfs), Bear (44% decline of 0.27 cfs) and Zayante above the Bean Creek confluence (32% decline of 0.9 cfs). Lower Zayante Creek declined 10% with a 0.5 cfs reduction. Boulder Creek declined only 0.1 cfs (9%).

Water Depth- Tributaries

Water depth was generally less in tributaries due to reduced streamflow. At comparable sampling sites in tributaries, average pool depth decreased at 10 of 19 sites from 2000 to 2001 (**Figure 32**). Maximum pool depth declined at 11 of 19 sites (**Figure 33).** However, this was not the case where scour occurred to deepen pools in all Bean Creek sites, Branciforte sites, lower Zayante, upper Boulder and somewhat in upper Kings, although average maximum depth did not increase in Kings and Branciforte creeks (**Figures 32 and 33**). Only runs/ step-runs in middle Bean and upper Bear creeks deepened in 2001 (upper Bean had to be moved in 2001) (**Figure 34**).

Table 20. Zayante Creek in Reach 13a; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000 from the San Lorenzo River Confluence to the Bean Creek Confluence.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth ft		% of Surveyed Portion	
	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00
POOL	10	12	988	1621	99	135	23	25	1.6	1.4	2.5	2.3	39.0	56.6
RUN	8	8	917	531	115	66	24	24	1.1	0.85	1.7	1.2	36.2	18.5
RIFFLE	12	8	631	399	53	50	22	29	0.7	0.65	1.1	1.0	24.9	13.9

Total Units Surveyed- 30/ 28; Total Length Surveyed- 2,536/ 2,865 ft.

Table 21. Zayante Creek in Reach 13b; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From the Bean Creek Confluence the Santa Cruz Aggregate Tributary.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth ft		% of Surveyed Portion	
	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	2000
POOL	20	17	2823	2264	141	133	17	19	1.4	1.5	2.6	2.8	80.0	75.6
RUN	7	10	260	416	37	42	16	19	0.8	0.8	1.2	1.1	7.4	13.9
RIFFLE	17	13	444	314	26	24	15	17	0.7	0.6	1.0	0.9	12.6	10.5

Total Units Surveyed- 44/ 40; Total Length Surveyed- 3,527/ 2,994 ft.

Table 22. Zayante Creek in Reach 13c; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From the Santa Cruz Aggregate Tributary to Lompico Creek.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth ft		% of Surveyed Portion	
	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	2000
POOL	19	19	2334	1938	130	102	16	17.5	1.4	1.5	2.5	2.5	71.6	70.0
RUN	8	9	495	367	62	41	13	13.5	0.7	0.7	1.0	1.1	15.2	13.2
STEP-RUN	1	0	16	0	16	0	10	0	1.1	0	1.5	0	0.5	0
GLIDE	0	2	0	82	0	41	0	16.5	0	0.4	0	0.55	0	3.0
RIFFLE	12	12	417	381	35	32	13	12	0.6	0.6	1.0	0.8	12.8	13.8

Total Units Surveyed- 40/ 42; Total Length Surveyed- 3,262/ 2,768 ft.

Table 23. Zayante Creek in Reach 13d; Summary of Habitat Types Characteristics in 1999 and 2000, Lompico Creek Confluence to Mountain Charlie Gulch.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth ft		% of Surveyed Portion	
	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	2000
POOL	22	25	1327	1430	60	57	14	16	1.4	1.3	2.1	2.1	52.5	54.4
RUN	4	6	102	248	26	41	13	13	0.8	0.8	1.0	1.2	4.0	9.4
STEP-RUN	16	12	1030	724	64	60	14	19	0.9	0.9	1.5	1.4	40.7	27.6
GLIDE	0	2	0	42	0	21	0	9	0	0.25	0	0.4	0	1.6
RIFFLE	3	8	70	183	23	23	10	7	0.4	0.6	0.8	1.0	2.8	7.0

Total Units Surveyed- 45/ 51; Total Length Surveyed- 2,529/ 2,627 ft.

Table 24. Bean Creek in Reach 14a; Summary of Habitat Types and Characteristics in 1999 and 2000, Zayante Creek Confluence to Mt. Hermon Road Bypass.

Habitat Type	Units Measured # 1999	'00	Total Length ft 1999	'00	Average Length ft 1999	'00	Average Width ft 1999	'00	Average Depth ft 1999	'00	Average Maximum Depth ft 1999	'00	% of Surveyed Portion 1999	2000
POOL	19	14	1223	964	64	69	15	15	1.3	1.2	2.2	2.0	50.8	38.4
RUN	8	9	484	667	61	74	15	17	0.6	0.65	1.0	1.2	20.1	26.6
GLIDE	0	6	0	219	0	36.5	0	16	0	0.6	0	0.8	0	8.7
RIFFLE	13	12	701	660	54	55	14	15	0.5	0.5	0.9	0.85	29.1	26.3

Total Units Surveyed- 40/ 41; Total Length Surveyed- 2,408/ 2,098 ft.

Table 25. Bean Creek in Reach 14b; Summary of Habitat Types and Characteristics in 1999 and 2000, Mt. Hermon Road Bypass to Ruins Creek Confluence.

Habitat Type	Units Measured # 1999	'00	Total Length ft 1999	'00	Average Length ft 1999	'00	Average Width ft 1999	'00	Average Depth ft 1999	'00	Average Maximum Depth ft 1999	'00	% of Surveyed Portion 1999	2000
POOL	35	30	2094	1438	60	48	12	12.5	1.1	1.1	1.9	1.6	65.6	48.0
RUN	15	15	389	532	26	35	11	12	0.4	0.6	0.7	1.0	12.2	17.8
GLIDE	0	9	0	343	0	12	0	12	0	0.5	0	0.6	0	11.5
RIFFLE	29	28	710	683	25	24	9	9	0.3	0.3	0.5	0.55	22.2	22.8

Total Units Surveyed- 79/ 82; Total Length Surveyed- 3,193/ 2,996 ft.

Table 26. Bean Creek in Reach 14c; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From the Ruins Creek Confluence to the Redwood Camp and Gradient Increase.

Habitat Type	Units Measured # 1999	'00	Total Length ft 1999	'00	Average Length ft 1999	'00	Average Width ft 1999	'00	Average Depth ft 1999	'00	Average Maximum Depth ft 1999	'00	% of Surveyed Portion 1999	'00
POOL	29	28	1356	1565	47	56	10	11	0.9	1.1	1.7	2.0	57.6	60.8
RUN	16	17	616	636	39	37	6	7	0.5	0.4	0.7	0.6	26.2	24.7
RIFFLE	18	20	383	375	21	19	6	4.5	0.2	2.5	0.5	0.5	16.3	14.6

Total Units Surveyed- 63/ 65; Total Length Surveyed- 2,355, 2,576 ft.

Table 27. Fall Creek in Reach 15; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From the San Lorenzo River Confluence to the Boulder-Bedrock Falls.

Habitat Type	Units Measured # 1999	'00	Total Length ft 1999	'00	Average Length ft 1999	'00	Average Width ft 1999	'00	Average Depth ft 1999	'00	Average Maximum Depth ft 1999	'00	% of Surveyed Portion 1999	2000
POOL	20	30	700	671	35	22	12	12	1.1	1.0	1.9	1.8	26.8	24.6
RUN	18	7	613	181	34	26	11	13	1.0	0.7	1.3	1.1	23.5	6.6
STEP-RUN	0	1	0	42	0	42	0	6	0	1.0	0	1.6	0	1.5
RIFFLE	28	40	1300	1832	46	46	10	8.5	0.6	0.6	1.1	1.0	49.8	67.2

Total Units Surveyed- 66/ 78; Total Length Surveyed- 2,613/ 2,726 ft.

Table 28. Newell Creek in Reach 16; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From the San Lorenzo River Confluence to the Bedrock Falls.

Habitat Type	Units Measured # 1999	'00	Total Length ft 1999	'00	Average Length ft 1999	'00	Average Width ft 1999	'00	Average Depth ft 1999	'00	Average Maximum Depth ft 1999	'00	% of Surveyed Portion 1999	2000
POOL	17	20	1421	1569	84	78	15	16	1.5	1.4	2.8	2.6	55.0	62.7
RUN	7	12	475	360	68	30	15	13	0.9	0.6	1.2	0.9	18.4	14.4
RIFFLE	17	20	687	574	40	29	14	15	0.5	0.4	0.7	0.65	26.6	22.9

Total Units Surveyed- 41/ 52; Total Length Surveyed- 2,583/ 2,503 ft.

Table 29. Boulder Creek in Reach 17a; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From the San Lorenzo River Confluence to the Foreman Creek Confluence.

Habitat Type	Units Measured # 1999	'00	Total Length ft 1999	'00	Average Length ft 1999	'00	Average Width ft 1999	'00	Average Depth ft 1999	'00	Average Maximum Depth ft 1999	'00	% of Surveyed Portion 1999	2000
POOL	14	20	1302	1521	93	76	17	20	2.3	1.8	3.5	2.7	45.1	49.4
RUN	7	10	561	571	80	57	19	20	0.7	0.8	1.3	1.2	19.4	18.5
STEP-RN	2	14	138	728	69	52	16	18	0.9	0.7	1.4	1.1	4.8	23.6
RIFFLE	19	9	884	261	47	29	17	17	0.7	0.6	1.1	1.0	30.6	8.5

Total Units Surveyed- 42/ 53; Total Length Surveyed- 2,885/ 3,081 ft.

Table 30. Boulder Creek Reach 17b; Summary of Habitat Types and Characteristics in 1999 and 2000, From Foreman Creek Confluence to the Narrow Canyon.

Habitat Type	Units Measured # 1999	'00	Total Length ft 1999	'00	Average Length ft 1999	'00	Average Width ft 1999	'00	Average Depth ft 1999	'00	Average Maximum Depth ft 1999	'00	% of Surveyed Portion 1999	2000
POOL	19	23	1230	1307	65	57	16	18	1.8	1.75	2.9	2.8	60.6	62.1
RUN	1	3	45	99	45	33	18	14	1.2	0.8	2.0	1.2	2.2	4.7
STEP-RN	2	12	191	548	96	46	15	9.5	0.8	0.7	1.5	1.2	9.4	26.0
RIFFLE	14	5	564	152	40	30	12	16	0.6	0.5	1.3	1.0	27.8	7.2

Total Units Surveyed- 36/ 43; Total Length Surveyed- 2,030/ 2,106 ft.

Table 31. Boulder Creek in Reach 17c; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From Narrowing of Canyon to Bedrock Cascade Adjacent the Kings Highway Junction with Big Basin Way.

Habitat Type	Units Measured # 1999	'00	Total Length ft 1999	'00	Average Length ft 1999	'00	Average Width ft 1999	'00	Average Depth ft 1999	'00	Average Maximum Depth ft 1999	'00	% of Surveyed Portion 1999	2000
POOL	11	12	1115	986	101	82	15	17	2.7	2.5	4.2	3.7	63.4	60.1
RUN	3	3	90	111	30	37	13	10	0.9	0.8	1.5	1.0	5.1	6.8
STEP-RN	1	9	50	435	50	48	23	12	0.9	0.8	1.1	1.3	2.8	26.5
RIFFLE	13	6	505	109	39	18	11	12	0.6	0.4	1.0	0.7	28.7	6.6

Total Units Surveyed- 28/ 30; Total Length Surveyed- 1,760/ 1,641 ft.

Table 32. Bear Creek in Reach 18a; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000*, From the San Lorenzo River to the Point of Increased Gradient and Unnamed Tributary Confluence.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth ft		% of Surveyed Portion	
	1999	'00	1999	2000	1999	'00	1999	'00	1999	'00	1999	'00	1999	2000
POOL	16	22	1889	2301	118	105	20	18	1.9	1.8	3.6	3.0	63.7	69.8
RUN	6	10	275	427	46	43	14	18	0.7	0.7	1.5	1.1	9.3	13.0
STEP-RUN	0	2	0	86	0	43	0	15.5	0	0.65	0	0.85	0	2.6
GLIDE	0	2	0	47	0	23.5	0	14.5	0	0.9	0	1.15	0	1.4
RIFFLE	12	13	804	437	67	34	11	12	0.7	0.5	1.1	0.8	27.1	13.2

Total Units Surveyed- 34/ 49
Total Length Surveyed- 2,967/ 3,298 ft. (Different surveyors between years.)

Table 33. Bear Creek in Reach 18b; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From the Gradient Increase to the Deer Creek Confluence.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth ft		% of Surveyed Portion	
	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	2000
POOL	23	14	1862	1017	81	73	16	14	1.8	1.4	2.9	2.4	59.6	64.9
RUN	4	2	194	58	49	29	12	8	0.6	0.5	1.2	1.0	6.2	3.7
STEP-RN	11	10	706	473	64	47	15	20	0.7	0.6	1.3	1.2	22.6	30.2
RIFFLE	16	2	362	18	23	9	13	6	0.4	0.4	0.7	0.55	11.6	1.2

Total Units Surveyed- 54/ 28;
Total Length Surveyed- 3,124/ 1,566 ft.

Table 34. Bear Creek in Reach 18b; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From the Gradient Increase to the Deer Creek Confluence. Same stream length compared.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth ft		% of Surveyed Portion	
	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	2000
POOL	10	14	907	1017	91	73	15	14	1.6	1.4	2.7	2.4	60.3	64.9
RUN	2	2	66	58	33	29	-	8	-	0.5	-	1.0	4.4	3.7
STEP-RN	6	10	362	473	60	47	-	20	-	0.6	-	1.2	24.1	30.2
RIFFLE	7	2	169	18	24	9	-	6	-	0.4	-	0.55	11.2	1.2

Total Units Surveyed- 25/ 28;
Total Length Surveyed- 1,504/ 1,566 ft.

Table 35. Kings Creek in Reach 19a; Summary of Habitat Types and Habitat Characteristics in

1999 and 2000, From the San Lorenzo River to the Southern, Unnamed Trib. at the Old Dam.

Habitat Type	Units Measured # 1999	Units Measured # '00	Total Length ft 1999	Total Length ft '00	Average Length ft 1999	Average Length ft '00	Average Width ft 1999	Average Width ft '00	Average Depth ft 1999	Average Depth ft '00	Average Maximum Depth ft 1999	Average Maximum Depth ft '00	% of Surveyed Portion 1999	% of Surveyed Portion 2000
POOL	25	32	1856	1829	74	57	13	12	0.8	1.7	1.5	1.3	64.9	68.1
RUN	8	13	627	302	78	23	10	8	0.5	0.4	0.8	0.6	21.9	11.2
STEP-RUN	0	2	0	73	0	37	0	5	0	0.5	0	0.7	0	2.7
GLIDE	0	1	0	37	0	37	0	10	0	0.4	0	0.6	0	1.4
RIFFLE	13	23	377	446	29	19	12	7.5	0.3	0.25	0.6	0.45	13.2	16.6

Total Units Surveyed- 46/ 43; Total Length Surveyed- 2,860/ 2,687 ft.

Table 36. Kings Creek in Reach 19b; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From the Southern, Unnamed Tributary at the Old Dam to the Boulder Falls.

Habitat Type	Units Measured # 1999	Units Measured # '00	Total Length ft 1999	Total Length ft '00	Average Length ft 1999	Average Length ft '00	Average Width ft 1999	Average Width ft '00	Average Depth ft 1999	Average Depth ft '00	Average Maximum Depth ft 1999	Average Maximum Depth ft '00	% of Surveyed Portion 1999	% of Surveyed Portion 2000
POOL	17	22	1375	1605	81	73	13	14	1.1	1.1	2.2	1.9	53.0	63.4
STEP-RN	10	13	752	791	75	61	12	15	0.7	0.55	1.2	0.9	29.0	31.4
RUN	7	3	281	110	40	37	16	10	0.7	0.4	1.3	0.6	10.8	4.4
RIFFLE	8	2	185	16	23	8	11	6.5	0.5	0.1	0.9	0.65	7.1	0.6

Total Units Surveyed- 42/ 40;
Total Length Surveyed- 2,593/ 2,522 ft.

Table 37. Carbonera Creek in Reach 20a; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From Branciforte Creek Confluence to the Old Road Crossing and Gradient Increase.

Habitat Type	Units Measured # 1999	Units Measured # 2000	Total Length ft 1999	Total Length ft 2000	Average Length ft 1999	Average Length ft '00	Average Width ft 1999	Average Width ft '00	Average Depth ft 1999	Average Depth ft '00	Average Maximum Depth ft 1999	Average Maximum Depth ft '00	% of Surveyed Portion 1999	% of Surveyed Portion 2000
POOL	22	26	1653	1593	75	91	13	13	1.0	1.0	2.1	2.0	64.9	63.1
RUN	13	13	540	461	42	35.5	7	8	0.4	0.3	0.6	0.5	21.2	18.3
RIFFLE	21	24	354	471	17	20	7	6	0.3	0.25	0.4	0.4	13.9	18.6

Total Units Surveyed- 56/ 63;
Total Length Surveyed- 2,547/ 2,525 ft.

Table 38. Carbonera Creek in Reach 20b; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From the Gradient Increase to Moose Lodge Falls.

Habitat Type	Units Measured # 1999	Units Measured # '00	Total Length ft 1999	Total Length ft 2000	Average Length ft 1999	Average Length ft '00	Average Width ft 1999	Average Width ft '00	Average Depth ft 1999	Average Depth ft '00	Average Maximum Depth ft 1999	Average Maximum Depth ft '00	% of Surveyed Portion 1999	% of Surveyed Portion 2000
POOL	23	22	1319	1082	57	49	14	15	1.4	1.35	2.3	2.1	50.5	47.9
RUN	10	14	353	528	35	37	10	12	0.5	0.55	0.7	0.9	13.5	23.4
STEP-RN	14	9	784	541	56	60	14	13.5	0.6	0.65	1.0	1.0	30.0	24.0
RIFFLE	9	8	156	106	17	13	9	7	0.4	0.3	0.6	0.55	6.0	4.7

Total Units Surveyed- 56/ 53;
Total Length Surveyed- 2,612/ 2,257 ft.

Table 39a. Branciforte Creek in Reach 21a-1; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From the Carbonera Creek Confluence to the Glen Canyon Creek Confluence.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth ft		% of Surveyed Portion	
	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	2000	1999
POOL	23	22	1824	2226	79	101	15	13	1.0	0.8	1.8	1.8	66.8	84.6
RUN	14	8	578	267	42	33	10	8	0.6	0.4	0.9	0.8	21.1	10.1
RIFFLE	19	13	330	139	17	11	8	6	0.3	0.3	0.5	0.5	12.1	5.3

Total Units Surveyed- 56/ 43;
Total Length Surveyed- 2,732/ 2,632 ft.

Table 39b. Branciforte Creek in Reach 21a-2; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From the Glen Canyon Creek Confluence to the Granite Creek Confluence.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth ft		% of Surveyed Portion	
	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	2000
POOL	28	26	1,608	1,923	57	74	19	16	1.1	1.05	1.9	2.0	67.9	65.6
RUN	12	13	470	540	39	42	9	10	0.5	0.6	0.8	0.9	19.8	18.4
RIFFLE	12	24	291	469	24	19.5	9	9	0.4	0.3	0.6	0.6	12.3	16.0

Total Units Surveyed- 52/ 63; Total Length Surveyed- 2,369/ 2,932 ft.

Table 40. Branciforte Creek in Reach 21b; Summary of Habitat Types and Habitat Characteristics in 1999 and 2000, From the Granite Creek Confluence to the Tie Gulch Confluence.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth ft		% of Surveyed Portion	
	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	'00	1999	2000
POOL	16	20	949	1113	59	56	13	12	1.2	1.0	2.1	1.7	46.9	61.4
RUN	6	7	220	142	37	20	10	10	0.8	0.4	1.1	0.6	10.9	7.8
RIFFLE	8	10	386	154	48	15	11	9	0.4	0.4	0.7	0.6	19.1	8.5
STEP-RN	7	9	469	405	67	45	10	11	0.7	0.5	1.0	0.85	23.2	22.3

Total Units Surveyed- 37/ 46; Total Length Surveyed- 2,024/ 1,814 ft.

Table 41. Habitat Changes from 2000 to 2001 in Tributary Sites of the San Lorenzo River. (Refer to footnotes for symbol explanations.)

Habitat Parameter	Branciforte	Carbonera	Zayante	Bean*	Fall	Newell	Boulder	Bear	Kings
Pool Escape cover	- +	- +	+	+	+	+	+	+ -	+
Max. Pool Depth	-	-	+ - + -	+	-	-	- - +	-	-
Mean Pool Depth	+	-	+ - + -	+	-	-	s - +	-	- +
Run/Stp-rn Mean Depth	-	s -	s - - -	- + +	+	+	-	- +	-
% Sand-Pools	-	s +	-	+ + s	+	+	s	+ -	-
% Sand-Riffles	s +	- s	s + + +	- + -	-	+	+ - +	-	+
% Sand-Stp-rn/ run	+ s	-	- - s s	- s -	-	+	- - +	- -	s -
Embeddedness- Riffle/Runs	+ -	-	-	- - +	+	+	- - +	- +	s -
Embeddedness- Pools	- +	+ s	- + - -	+ s +	-	-	- + +	+ -	+ -

\+ Denotes improvement in habitat condition.

\- Denotes worsening in habitat condition.

\- + Denotes worsening in the lower reach and improvement in the upper reach. Zayante Creek had 4 reaches. Bean and Boulder creeks had 3 reaches.

S Denotes same or similar habitat conditions in both 2000 and 2001.

* Upper Bean Creek Site had to be moved because the 2000 site was dry.

Table 42. STREAMBED SEDIMENTATION Expressed as Average Percent Fine Sediment by Habitat Type in Tributary Reaches, 1998-2000 and at Tributary Sampling Sites in 2000 and 2001.

Habitat Type
(Percent Sand and Silt Averaged by Reach- Visually Estimated)

Reach #		Pool				Riffle				Run/Step-run			
		1998	1999	2000	2001	1998	1999	2000	2001	1998	1999	2000	2001
Zayante	13a	70*	70	80/60	65	35	30	30/35	35	50	65	55/50	70
	13b	70	75	80/75	90	10	40	30/35	40	40	55	45/40	70
	13c	65	75	55/30	40	25	50	20/20	30	45	40	25/30	30
	13d	65	70	60/55	75	50	45	25/35	40	35	45	45/40	40
Bean	14a	80	75	80/95	85	45	45	45/50	70	75	65	70/50	70
	14b	70	70	80/85	80	10	15	25/30	20	70	30	60/35	35
	14c**	75	70	70/80	80	50	30	25/5	20	60	40	35/35	60
Fall	15	55	50	75/75	60	35	40	50/20	25	55	55	65/55	70
Newell	16	55	35	50/30	40	20	10	20/20	10	20	10	35/35	25
Boulder	17a	45	60	45/50	50	20	30	30/30	15	25	35	30/25	30
	17b	45	50	40/45	45	20	30	10/15	20	45	30	25/15	25
	17c***	60	75	45/40	40	-	20	5/10	5	20	35	20/15	10
Bear	18a	75	60	55/55	45	20	15	15/15	30	10	10	30/20	30
	18b	70	55	40/40	55	30	20	10/-	5	50	35	25/10	30
Kings	19a	50	50	55/10	60	20	20	40/40	15	35	25	45/30	30
	19b	65	75	60/65	70	15	20	20/-	25	25	35	40/40	45
Carbo-nera	20a	-	75	90/90	90	-	20	50/70	60	-	40	55/60	70
	20b	30	60	55/75	60	-	20	15/5	5	30	45	35/25	40
Branci-forte	21a-1	-	45	85		-	20	25		-	35	65	
	21a-2	50	55	65/35	60	20	25	30/15	15	25	35	55/85	40
	21b**	65	65	65/60	70	30	40	30/20	15	40	45	40/45	45

* Average Percent Rounded to the Nearest 5%.
** Surveyed Segment in 1999 and 2000 was further upstream than in 1998; 2001 site upstream of 2000 site because of dewatering and the same as 1999 site.
*** Surveyed Segment in 1999 and 2000 was further downstream than in 1998.

Fish Population Monitoring- Mainstem River

Appendix C contains capture data from electrofishing. **Table 44** and **Figures 1 and 3** summarize site densities by size-class in the mainstem River in 2001 and then at comparable sites in 1997-2001. **Table 45** and **Figure 6** summarizes site densities of age classes for the mainstem River. **Tables 46-49** summarize reach densities of size classes, age classes and total juvenile densities based on habitat proportions. **Tables 50-53** and **Figures 10-18** summarize reach production and accumulated numbers up through the mainstem reaches for size classes, age classes and total production based on habitat proportions. **~~Tables 1a-c of reach and site descriptions are repeated on pages 141-144 before the Figures.~~**

Statistical Analysis of Annual Differences in Juvenile Densities at Sampling Sites

The trend in fish densities between 2000 and 2001 was analyzed by using a paired t-test (Snedecor and Cochran 1967; Sokal and Rohlf, 1995) on the fish densities of 34 sites for each age and size class (SC1,SC2,AC1,AC2). Site 14c (upper Bean Creek) was not used because the specific site was changed between 2000 and 2001 because the site location in 2000 was dry in 2001. The paired t-test is among the most powerful of statistical tests. This test was possible because the data were taken at the same site each year as opposed to re-randomizing each year. The null hypothesis for the test was that among all sites, the site-by-site difference from year 2000 to 2001 was zero. The lower mainstem River (Sites 0b-9) was analyzed in a separate t-test and the upper mainstem plus the tributaries (Sites 10-21b) in a separate t-test. The results are presented below in **Tables 43a-c**. Both Size Class 1 and Age Class 1 increased in density over the whole basin (**Table 43a**) by more than 8 fish per 100 feet. This difference was highly significant statistically. The p-value is the probability that the data (fish densities) are consistent with that hypothesis. Hence a p-value of .05 means that there is only a 5% probability that the difference between densities was zero. A 2-tailed test means that an increase or a decrease was tested for. The confidence limits tell us the limits of where the true mean difference was. The 95% confidence interval means that there is a 95% probability that the true mean difference lies between these limits. If these limits included zero, then it could not be ruled out that there was no difference between 2000 and 2001 densities. The 95% confidence limits are standard and a p-value of < 0.05 is considered significant.

Both Size Class 2 and Age Class 2 decreased by slightly more than 1 fish per 100 feet. But the difference was not statistically significant due to variation and the small difference seen. The difference could be due to chance alone. The results were essentially the same both in significance and magnitude for the two subdivisions of the basin (**Tables 43b and 43b**), yielding significant increases in Size Class 1 and Age Class 1 for the mainstem sites and separately for the upper mainstem with tributary sites.

Table 43a. T-test for the Trend (2000-2001) in Size Class Densities for All Fish Sampling Sites.

	s.c.1-2000	*s.c.1-2001*
Mean density	18.76470588	27.52058824
Variance	294.8217469	362.4386542
Hypothesized Mean Difference	0	
Df	33	
t Stat	3.518469744	
P(T<=t) two-tail	0.001288794	
95% CL upper	13.8188722	
95% CL lower	3.692892506	

	s.c.2-2000	*s.c.2-2001*
Mean	9.95	8.555882353
Variance	41.17469697	20.60193405
Hypothesized Mean Difference	0	
df	33	
t Stat	1.254373748	
P(T<=t) two-tail	0.218518564	
95% CL upper	0.867053462	
95% CL lower	-3.65528876	

	a.c.1-2000	*a.c.1-2001*
Mean	21.47941176	30.29411765
Variance	253.596836	276.6314795
Hypothesized Mean Difference	0	
df	33	
t Stat	3.864370925	
P(T<=t) two-tail	0.00049362	
95% CL upper	13.45547518	
95% CL lower	4.17393658	

	a.c.2-2000	*a.c.2-2001*
Mean	7.638235294	6.355882353
Variance	35.82182709	26.54314617
Hypothesized Mean Difference	0	
df	33	
t Stat	-1.38510299	
P(T<=t) two-tail	0.175313637	
95% CL upper	0.601237441	
95% CL lower	-3.16594332	

Table 43b. T-test for Trend (2000-2001) in Size Class Densities at Sampling Sites (0b-9) in the Mainstem, Downstream of Boulder Creek.

	s.c.1-2000	*s.c.1-2001*
Mean	2.536363636	10.87272727
Variance	8.306545455	82.55618182
Hypothesized Mean Difference	0	
df	10	
t Stat	4.171285582	
P(T<=t) two-tail	0.001914048	
95% CL upper	12.78932552	
95% CL lower	3.883401753	

	s.c.2-2000	*s.c.2-2001*
Mean	8.436363636	9.145454545
Variance	73.76054545	29.40072727
Hypothesized Mean Difference	0	
df	10	
t Stat	0.305884235	
P(T<=t) two-tail	0.765965803	
95% CL upper	5.87429011	
95% CL lower	-4.45610829	

	a.c.1-2000	*a.c.1-2001*
Mean	9.2	17.05454545
Variance	79.034	97.83272727
Hypothesized Mean Difference	0	
df	10	
t Stat	2.88055376	
P(T<=t) two-tail	0.016369984	
95% CL upper	13.93011958	
95% CL lower	1.778971328	

	a.c.2-2000	*a.c.2-2001*
Mean	1.809090909	1.809090909
Variance	2.222909091	3.708909091
Hypothesized Mean Difference	0	
Df	10	
t Stat	1.48E-17	
P(T<=t) two-tail	0.99999999	
95% CL upper	0.761251955	
95% CL lower	-0.76125195	

Table 43c. T-test for Trend (2000-2001) in Size Class Densities at Sampling Sites in the Upper Mainstem and Tributary Sites(10-21b).

	s.c.1-2000	*s.c.1-2001*
Mean	26.52608696	35.4826087
Variance	243.8001976	301.281502
Hypothesized Mean Difference	0	
df	22	
t Stat	2.497762	
P(T<=t) two-tail	0.020466918	
95% CL lower	16.39305461	
95% CL upper	1.519988869	

	s.c.2-2000	*s.c.2-2001*
Mean	10.67391304	8.273913043
Variance	26.54110672	17.28201581
Hypothesized Mean Difference	0	
df	22	
t Stat	-2.0079801	
P(T<=t) two-tail	0.057080287	
95% CL lower	0.078757322	
95% CL upper	-4.87875732	

	a.c.1-2000	*a.c.1-2001*
Mean	27.35217391	36.62608696
Variance	233.0216996	240.9183794
Hypothesized Mean Difference	0	
df	22	
t Stat	2.948748845	
P(T<=t) two-tail	0.007424197	
95% CL lower	15.79631271	
95% CL upper	2.751513373	

	a.c.2-2000	*a.c.2-2001*
Mean	10.42608696	8.530434783
Variance	27.60747036	22.84857708
Hypothesized Mean Difference	0	
df	22	
t Stat	-1.404229	
P(T<=t) two-tail	0.174211385	
95% CL lower	0.903992317	
95% CL upper	-4.69529667	

Site and Reach Densities and Production of Juvenile Steelhead in Size Class 1 (<75 mm Standard Length) and the Young-of-the-Year Age Class

Site densities in 2001 for steelhead <75 mm SL (Size Class 1) were higher than in 2000 at all sites where they were present except the uppermost Site 12b and were higher than in 1999 at 9 of 13 sites (**Table 44; Figure 3**) due to more young-of-the-year (YOY) fish (at least compared to 2000) and slower growth rate (**Table 45; Figure 7**). Site 2b in the secondary channel of the Rincon area had slightly higher densities of YOY fish than the mainstem Site 2a; 12.1 fish/ 100 ft compared to 11.0 and only about 60% that of 2000 in the secondary channel. However, density of Size Class 1 fish was higher in 2001 due to less flow and slower growth rate there. In 2001, reach densities of Size Class 1 juveniles in the mainstem were relatively low at less than 20 fish per 100 feet in 7 of 12 reaches, despite the reduced growth rate (**Table 46**). Some of the higher production areas were in Reaches 6 and 8-12 (**Table 50; Figure 10**). However, Reaches 7-11 have been much more productive in earlier years. Regarding overall densities of Size Class 1 juveniles for the three segments of the mainstem in the last 5 years, 2001 had the second highest density in the lower River, third highest density in the middle River and second highest density in the upper River (**Table 48**). Reach production of Size Class 1 fish in 2001 was more than double that of 2000 in 8 of 11 reaches where they were present in both years, and overall mainstem production was nearly double in 2001 (23,600 fish) compared to 2000 (**Tables 51 and 56**).

For 2001, mainstem reach densities of YOY fish were more than 10 fish/ 100 feet for all reaches except Reaches 0 and 7. Where as for 2000, densities below 10 fish /100 feet had occurred for all reaches except Reaches 3 and 10-12 (**Table 47**). Production of YOY fish was greater in 2001 than 2000 in all mainstem reaches except 3 and 12 (**Table 52; Figure 11**), but was still considerably lower than pre El Niño production in 1997. Regarding overall densities of YOY juveniles for the three segments of the mainstem in the last 5 years, 2001 had the fourth highest density in the lower River, fourth highest density in the middle River and second highest density in the upper River (**Table 49**). Mainstem reach production of YOY fish in 2001 doubled over 2000 in many reaches and was nearly double the overall mainstem production in 2001 (30,400 fish) compared to 2000 (**Tables 53 and 57; Figure 15**). However, 2001 YOY production in the mainstem was still the second lowest in the last 5 years.

Table 44. Density of Juvenile Steelhead by SIZE-CLASS at MAINSTEM MONITORING SITES in the San Lorenzo River Drainage in 1997-2001. Sites were sometimes sampled in different habitats in 1997-2001 compared to previously. Underwater visual censusing of deep pools with fewer steelhead began in 1998.

Sample Site	1997 Densities*			1998 Densities			1999 Densities			2000 Densities			2001 Densities		
	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes
0a										0	5.4	5.4			
0b										0	4.3	4.3	0	5.2	5.2
1	3.3	30.9	34.2	0.2	26.7	26.9	2.2	15.4	17.6	0	3.4	3.4	0.7	6.9	7.6
2a	7.9	67.0	74.9	1.3	20.1	21.4	0.4	4.2	4.6	0.2	3.7	3.9	2.5	11.0	13.5
2b										1.2	23.6	24.8	6.7	8.7	15.4
3	47.7	36.2	83.9	9.4	64.1	73.5	3.7	25.3	29.0	5.9	27.1	33.0	18.1	17.9	36.0
4	63.0	23.8	86.9	8.6	29.2	37.8	6.8	32.8	39.6	3.1	8.9	12.0	17.6	15.5	33.1
5	-	-	-	19.1	114.7	133.8	5.2	41.0	46.2	0	4.5	4.5	8.1	15.5	23.6
6	35.1	10.3	45.4	20.5	25.5	46.0	11.2	2.9	14.1	1.8	2.2	4.0	8.4	2.5	10.9
7	126.7	22.6	149.3	11.7	10.0	21.7	2.9	8.9	11.8	1.5	6.1	7.6	8.6	6.9	15.5
8	138.6	20.0	158.6	118.7	21.4	140.1	37.4	10.8	48.2	8.0	3.2	11.2	20.5	9.3	29.8
9	102.2	24.6	126.8	57.5	19.8	77.3	18.5	9.1	27.6	6.2	5.8	12.0	28.4	1.2	29.6
10	65.8	3.3	69.1	9.6	8.3	17.9	4.4	6.5	10.9	10.1	8.3	18.4	12.2	7.5	19.7
11	64.2	8.8	73.0	4.1	6.8	10.9	26.9	6.5	33.4	15.6	13.1	28.7	18.7	6.4	25.1
12a	50.9	5.9	56.8	26.2	4.6	30.8	5.4	15.7	21.1	34.4	5.5	39.9	40.3	9.5	49.8
12b	-	-	-	19.5	12.7	32.2	4.1	21.8	25.9	37.0	6.5	43.5	17.4	13.0	30.4

*** Density in number of fish per 100 feet of stream.**

Table 45. Density of Juvenile Steelhead by Age Class at MONITORING SITES in the Mainstem San Lorenzo River in 1997-2001.

Sampling Site *		Densities** Y-O-Y's 1997	1998	1999	2000	2001	Yearlings and 2+ 1997	1998	1999	2000	2001
SLR- Below Hwy 1	#0a				2.2					2.2	
SLR- Above Hwy 1	#0b				3.3	2.3				1.0	2.9
SLR- Paradise Park	#1	32.3	25.6	12.6	1.8	6.8	1.6	1.4	2.9	1.9	0.5
SLR- Rincon Primary	#2a	66.3	19.2	3.2	2.7	11.0	7.9	1.5	0.9	1.2	1.5
SLR- Rincon Secondary	#2b				21.2	12.1				2.4	2.0
SLR- Upper Gorge	#3	84.3	68.2	24.7	29.4	29.6	5.2	5.3	3.9	4.4	6.6
SLR- Below Felton	#4	86.2	32.9	34.2	10.5	30.5	7.6	4.7	2.2	1.2	0.5
SLR- Below Zayante	#5	-	132.4	38.5	3.5	22.8	-	2.9	5.4	1.0	0.8
SLR- Near Fall Cr.	#6	42.0	44.4	13.2	3.3	10.6	4.6	2.2	0.8	0.7	0.5
SLR- Ben Lomond	#7	143.5	19.8	5.7	3.6	12.0	6.0	2.5	6.3	4.8	3.6
SLR- Below Clear Cr	#8	152.0	135.3	44.2	10.9	21.0	5.4	4.2	4.1	0.3	0.4
SLR- Below Boulder Cr	#9	119.9	69.7	23.4	11.0	28.9	4.3	8.1	2.5	1.0	0.6
SLR- Below Kings Cr	#10	65.8	11.7	6.5	13.4	15.9	3.3	6.4	4.6	5.5	4.1
SLR- Below Teilh Rd	#11	64.2	6.8	27.6	16.4	21.8	8.8	3.9	6.5	11.2	4.7
SLR- Below Highway 9 (Waterman Gap)	#12a	50.9	27.9	5.4	34.4	37.3	5.9	3.2	15.7	5.5	12.9
SLR- Above Highway 9 (Waterman Gap)	#12b	-	24.2	14.3	37.9	15.8	-	6.8	12.6	5.5	14.3

Table 46. Estimated DENSITY of Juvenile Steelhead by SIZE-CLASS and REACH in the San Lorenzo River Mainstem in 1997-2001, Using Habitat Proportions Based on Annual Habitat Typing.

	Density in Number of Juveniles per 100 feet of Stream Reach														
	1997			1998			1999			2000			2001		
Reach*	SC#1*	SC#2/3	Both Sizes	SC#1	SC#2/3	Both Sizes	SC#1	SC#2/3	Both Sizes	SC#1	SC#2/3	Both Sizes	SC#1	SC#2/3	Both Sizes
0										0	4.4	4.4	0	4.7	4.7
1	3.6	34.2	37.8	0.4	25.2	25.6	0.4	41.0	41.4	0	5.4	5.4	1.2	10.4	11.6
2	5.1	65.8	70.9	7.4	61.3	68.7	1.0	19.3	20.3	0.5	8.0	8.5	5.2	15.0	20.2
3	47.7	34.1	81.8	8.6	48.3	56.8	6.5	45.0	51.5	9.8	37.1	46.9	24.2	22.2	46.4
4	51.1	15.4	66.4	8.7	21.8	30.5	12.4	55.4	67.8	4.5	8.5	13.0	19.6	48.8	68.4
5	43.0	9.9	52.9	6.6	41.6	48.2	5.5	37.8	43.3	0.3	2.7	3.0	9.1	15.8	24.9
6	16.4	5.1	21.6	8.1	6.9	15.0	32.0	6.8	38.8	3.1	4.2	7.3	20.1	4.2	24.5
7	67.2	12.5	79.8	22.3	16.4	38.7	7.2	14.9	22.1	1.2	5.9	7.1	6.5	4.9	11.4
8	89.1	20.0	109.0	111.6	22.6	134.3	21.6	9.3	30.9	7.3	2.9	10.2	25.3	1.1	26.4
9	103.7	28.1	131.8	90.6	23.9	114.5	16.6	8.2	24.8	4.8	4.5	9.3	25.1	0.9	26.0
10	53.0	5.5	58.5	7.2	7.0	14.2	4.5	1.4	5.9	14.5	8.0	22.5	16.6	7.3	23.9
11	66.5	9.2	75.7	3.7	7.0	10.7	26.0	5.9	31.9	17.8	14.0	31.8	24.4	8.7	33.1
12	53.3	7.9	61.2	24.3	7.6	31.9	4.6	18.2	22.8	34.2	7.4	41.6	29.1	10.9	40.0

***SC#1 are juveniles <75 mm SL; SC#2/3 are juveniles =>75 mm SL.**

*** Reach designations specified in Table 1a and mapped in Appendix A; Figure 2.**

Table 47. Estimated DENSITY of Juvenile Steelhead by AGE-CLASS and REACH in the San Lorenzo River MAINSTEM in 1997-2001, Using Habitat Proportions Based on Annual Habitat Typing.

Density in Number of Juveniles per 100 feet of Stream Reach

	1997			1998			1999			2000			2001		
Reach*	YOY	Yearlings	Both Sizes	YOY	Yearlings	Both Sizes	YOY	Yearlings	Both Sizes	YOY	Yearlings	Both Sizes	YOY	Yearlings	Both Sizes
0										2.7	1.6	4.3	2.5	3.1	5.6
1	35.1	1.2	36.3	24.3	1.2	25.5	34.1	7.1	41.2	2.1	3.3	5.4	10.2	0.9	11.1
2	61.1	5.6	66.7	66.0	5.0	71.0	16.3	2.9	19.2	8.1	2.0	10.1	19.0	1.1	20.1
3	82.1	4.9	87.0	50.9	3.9	54.8	44.2	6.5	50.7	45.3	6.3	51.6	37.3	9.2	46.5
4&5	67.8	4.4	72.2	31.4	2.7	34.0	55.9	6.0	61.9	9.8	0.9	10.7	31.1	0.4	31.5
6	19.9	2.5	22.4	23.7	1.3	25.0	37.7	1.5	39.2	6.1	1.3	7.4	22.2	0.9	23.1
7	78.1	6.2	84.3	34.9	5.2	40.2	12.3	10.1	22.4	3.1	3.9	7.0	9.0	2.6	11.6
8	99.5	8.4	108.0	129.3	5.1	134.4	26.3	4.7	31.0	9.9	0.1	10.0	25.9	0.5	26.4
9	121.3	16.3	137.6	107.4	8.8	116.2	21.0	2.3	23.3	8.5	0.7	9.3	25.6	0.5	26.1
10	53.0	5.5	58.5	7.4	7.0	14.4	6.3	5.1	11.4	16.7	5.3	22.0	21.1	3.4	24.5
11	66.5	9.2	75.7	6.6	4.0	10.6	26.8	5.5	32.3	18.4	12.1	30.5	29.5	5.9	35.4
12	53.3	7.9	61.2	27.4	4.6	32.0	9.2	13.2	22.4	34.6	6.9	41.5	26.8	13.3	40.1

*** Reach designations specified in Table 1a and mapped in Appendix A; Figure 2.**

Table 48. Annual Comparisons of Estimated OVERALL DENSITY* of Juvenile Steelhead Produced by SIZE-CLASS in REACHES of the Mainstem San Lorenzo River, 1997-2001.

Reach	1997 SC#1*	1997 SC#2/3	1997 All Sizes	1998 SC#1	1998 SC#2/3	1998 All Sizes	1999 SC#1	1999 SC#2/3	1999 All Sizes	2000 SC#1	2000 SC#2/3	2000 All Sizes	2001 SC#1	2001 SC#2/3	2001 All Sizes
1-5 Lower SLR (7.6 miles)	22.3	36.0	58.3	5.2	36.6	41.8	4.2	39.7	43.9	2.5	14.9	17.4	8.2	13.1	21.3
6-9 Middle SLR (8.9 miles)	60.8	14.9	75.7	51.7	18.1	69.8	21.7	9.2	30.9	3.9	4.4	8.3	19.8	3.0	22.8
10-12 Upper SLR (8.3 miles)	58.5	7.7	66.2	10.9	7.9	18.8	13.1	9.6	22.7	21.7	10.2	31.9	23.5	9.0	32.5

*** SC#1 = fish < 75 mm SL; SC#2/3 = fish => 75 mm SL**

*** Density in fish per 100 feet of stream.**

Table 49. Annual Comparisons of Estimated OVERALL DENSITY* of Juvenile Steelhead Produced by AGE-CLASS in COMBINED REACHES of the LOWER, MIDDLE AND UPPER MAINSTEM San Lorenzo River, 1997-2001.

Reach	1997 YOY	1997 Year-lings	1997 All Ages	1998 YOY	1998 Year-lings	1998 All Ages	1999 YOY	1999 Year-lings	1999 All Ages	2000 YOY	2000 Year-lings	2000 All Ages	2001 YOY	2001 Year-lings	2001 All Ages
1-5 Lower SLR (7.6 miles)	56.2	3.6	59.8	39.2	2.8	42.0	39.2	5.5	44.7	12.3	3.1	15.4	18.7	2.1	20.8
6-9 Middle SLR (8.9 miles)	70.4	7.6	78.0	66.3	4.5	70.8	26.8	3.9	30.7	6.8	1.4	8.2	21.3	1.0	22.3
10-12 Upper SLR (8.3 miles)	58.5	7.7	66.2	10.9	7.9	18.8	15.4	7.7	23.1	22.7	8.5	31.2	26.2	7.4	33.6

*Density in fish per 100 feet of stream for combined reaches of each of the three regions.

Reach and Site Densities and Production of Larger Juvenile Steelhead, =>75 mm Standard Length and the Yearling and Older Age Classes- Mainstem

Site densities of juvenile steelhead =>75 mm SL (Size Classes 2 and 3) were higher in 2001 than in 2000 at 10 of 15 mainstem sites, with yearling density higher at only 6 of 15 sites (**Tables 44 and 45; Figures 4 and 9**). In contrast to the trend of similar or fewer yearlings at most mainstem sites, Sites 12a and 12b in Waterman Gap had more than double the 2000 density in 2001. Site 2b in the secondary channel of the Rincon area had much fewer large fish and about the same density of yearlings compared to 2000.

In 2001, the highest reach densities of Size Class 2 and 3 juveniles in the mainstem were in Reaches 2-5, with values between 15 and 48.4 fish/ 100 feet. Reach 4 showed the biggest improvement over 2000 (**Table 46**). Reach densities were greater in 2001 than 2000 in only 5 of 13 reaches, but they were substantially higher. Six of 12 reaches had less than 10 large juveniles per 100 feet and 4 of 12 had densities of 15 fish/ 100 feet or more. In 2000, only 1 of 12 reaches had densities of 15 fish/ 100 feet or more for larger fish. In 1997, 6 of 12 reaches had densities of 15 fish/ 100 feet or more for larger fish.

The highest densities of yearlings in 2001 were in Reaches 3 and 12 (**Table 47**), with only 3 of 13 reaches having higher densities in 2001 than in 2000.

Regarding overall densities of Size Class 2 and 3 juveniles for the three segments of the mainstem in the last 5 years, 2001 had the lowest density in the lower River, the lowest density in the middle River and third highest density in the upper River (**Table 48**). Reach production of larger juveniles was higher in 2001 than 2000 only in Reaches 1, 2, 4 and 12 (**Table 50; Figure 12**). Overall, estimated mainstem reach production of Size Class 2 and 3 fish was very similar in 2001 (11,400 fish) to 2000 in overall mainstem production (**Tables 51 and 56; Figure 16**).

Regarding overall densities of yearling juveniles for the three segments of the mainstem in the last 5 years, 2001 had the lowest density in the lower, middle and upper River (**Table 49**). Reach production of yearlings was higher in 2001 than 2000 in only Reaches 3, 8 and 12 (**Table 52; Figure 13**). Overall, estimated mainstem reach production of yearlings in 2001 (4,600 fish) was the lowest in 5 years and approximately 80% of 2000 production (**Table 53 and 57; Figure 17**).

Total Density and Production of Juvenile Steelhead at Mainstem Sites and Reaches of the San Lorenzo River.

In 2001, site densities of combined sizes of juveniles were higher than in 2000 at 12 of 15 sites because of the increase in YOY fish in 2001 (**Table 44**). The exceptions were Site 2b and 3 of 4 sites in the upper River. The highest site density in the lower River in 2001 as in 2000 was at Site 3 with 36 fish/ 100 ft, compared to 33 in 2000, 46.2 in 1999, 133.8 in 1998 and 86.9 in 1997 in the lower

River. In the middle River in 2001, Sites 8 and 9 were similar at 29.8 and 29.6 fish/ 100 ft, respectively. Site 9 had the highest density in 2000 at 12 fish/ 100 ft, compared to 48.2 at Site 8 in 1999, 140.1 at Site 8 in 1998 and 158.6 in 1997. The lower Waterman Gap Site 12a had the highest fish density in the upper River at 49.8 fish/ 100 ft compared to 43.5 in Site 12b in 2000, 33.4 in Site 11 in 1999, 32.2 in Site 12b in 1998 and 73 in Site 11 in 1997.

When habitat proportions were factored in to determine reach densities of combined size classes, Reaches 3 and 4 had the highest in 2001 at 46.4 and 68.4 fish/ 100 ft, while Reaches 3 and 12 had the highest in 2000 at 47 and 42 fish/ 100 feet, while Reaches 3 and 4 were the highest in 1999 at 52 and 68 fish/ 100 feet, Reaches 8 and 9 were highest in 1998 at 134 and 114 fish/ 100 feet and Reaches 8 and 9 were the highest in 1997 at 109 and 131.8 fish/ 100 ft, respectively (**Table 46**). In 2001, 4 reaches (3, 4, 11 and 12) were in the 30-70 fish/ 100 ft range, while in 2000, three reaches (3, 11 and 12) were in the 30-45 fish/ 100 feet range and in 1999, five reaches (1, 5, 6, 8 and 11) were in that range. In 1999-2001, pools were largely unused in Reaches 1-9, though pool densities increased throughout the mainstem under the high baseflows of 1998. In Reaches 11 and 12 with lower water temperature than downstream, pools were shorter and fastwater habitat was in close proximity at pool heads having adequate escape cover. Therefore, pools in Reaches 11 and 12 had more steelhead than pools elsewhere in the mainstem.

The three reaches that produced the most juvenile steelhead of all sizes were Reaches 6, 11 and 12 (**Table 50; Figure 14**). Reaches 11 and 12 had been most productive in 2000. Of the last 5 years, 2001 was the second lowest in total production at 35,300 fish, ahead of 2000 (**Table 56; Figure 18**). The low production was due mostly to the low number of yearlings in the mainstem (**Figure 17**). The proportions of juveniles in the lower, middle and upper River in 2001 were 29%, 30% and 40%, respectively (**Table 55**), compared to 28%, 16% and 56% in 2000. This indicated that more YOY fish utilized the middle River than in 2000.

Table 50. Estimated NUMBER of Juvenile Steelhead by SIZE-CLASS and REACH in the San Lorenzo River Mainstem in 1997-2001 using Annual Habitat Proportions Determined During Habitat-Typing.

	1997			1998			1999			2000			2001		
*Reach**	SC#1	SC#2/3	All Sizes	SC#1	SC#2/3	All Sizes	SC#1	SC#2/3	All Sizes	SC#1	SC#2/3	All Sizes	SC#1	SC#2/3	All Sizes
0										0	230	230	0	344	344
1	537	5,072	5,609	63	3,735	3,798	55	6,088	6,143	0	796	796	185	1,538	1,723
2	454	5,871	6,325	658	5,468	6,126	88	1,722	1,810	55	836	891	529	1,525	2,054
3	2,720	1,942	4,662	488	2,753	3,241	369	2,566	2,935	560	2,117	2,677	1,380	1,264	2,644
4	4,367	1,317	5,684	745	1,868	2,613	1,057	4,743	5,800	383	731	1,114	1,676	1,370	3,046
5	872	200	1,072	134	842	976	112	765	877	7	55	62	185	320	505
6	2,934	915	3,849	1,451	1,227	2,678	5,716	1,223	6,939	550	758	1,308	3,583	758	4,341
7	5,893	1,096	6,989	1,958	1,436	3,394	632	1,309	1,941	101	517	618	571	433	1,004
8	8,139	1,824	9,963	10,200	2,068	12,268	1,978	852	2,830	663	265	928	2,309	103	2,412
9	11,549	3,132	14,681	10,091	2,659	12,750	1,849	915	2,764	533	503	1,036	2,800	98	2,898
10	6,991	729	7,720	951	930	1,881	592	790	1,382	1,910	1,053	2,963	2,191	970	3,161
11	11,756	1,633	13,389	662	1,246	1,908	4,596	1,042	5,638	3,151	2,468	5,619	4,311	1,538	5,849
12	7,031	1,046	8,077	3,213	997	4,210	602	2,402	3,004	4,508	977	5,485	3,843	1,440	5,283
TOTALS:	63.2k*	24.6k	88.0k	31.2k	26.6k	57.8k	17.6k	24.4k	42.1k	12.4k	11.3k	23.7k	23.6k	11.7k	35.3k

*** "k" = thousands; SC#1 = fish that are <75 mm SL; SC#2/3 = fish that are =>75 mm SL**

*** Reach designations specified in Table 1a and mapped in Appendix A; Figure 2.**

Table 51. Estimated NUMBER of Juvenile Steelhead in the Mainstem San Lorenzo River, ACCUMULATED by Reach in 1997-2001, in SIZE CLASSES using Habitat Proportions Determined by Habitat-Typing.

	1997			1998			1999			2000			2001		
*Reach**	SC#1	*SC#2/3*	All Sizes	SC#1	*SC#2/3*	All Sizes	SC#1	*SC#2/3*	All Sizes	SC#1	*SC#2/3*	All Sizes	SC#1	*SC#2/3*	All Sizes
1	537	*5,072*	5,609	63	*3,735*	3,798	55	*6,088*	6,143	0	*796*	796	185	*1,538*	1,723
2	991	*10,943*	11,934	721	*9,203*	9,924	143	*7,810*	7,953	55	*1,632*	1,687	714	*3,063*	3,777
3	3,711	*12,885*	16,596	1,209	*11,956*	13,165	512	*10,376*	10,888	615	*3,749*	4,364	2,094	*4,327*	6,421
4	8,078	*14,202*	22,280	1,954	*13,824*	15,778	1,569	*15,119*	16,688	998	*4,480*	5,478	3,770	*5,697*	9,467
5	8,950	*14,402*	23,352	2,088	*14,666*	16,754	1,681	*15,884*	17,565	1,005	*4,535*	5,540	3,955	*6,017*	9,972
6	11,884	*15,317*	27,201	4,093	*16,984*	21,077	7,397	*17,107*	24,504	1,555	*5,293*	6,848	7,538	*6,775*	14,313
7	17,777	*16,413*	34,190	6,051	*18,420*	24,471	8,029	*18,416*	26,445	1,656	*5,810*	7,466	8,109	*7,206*	15,315
8	25,916	*18,237*	44,153	16,251	*20,488*	36,739	10,007	*19,268*	29,275	2,319	*6,075*	8,394	10,418	*7,311*	17,729
9	37,465	*21,369*	58,834	26,342	*23,147*	49,489	11,856	*20,183*	32,039	2,852	*6,578*	9,430	13,218	*7,409*	20,627
10	44,456	*22,098*	66,554	27,293	*24,328*	51,621	12,448	*20,973*	33,421	4,762	*7,631*	12,393	15,409	*8,379*	23,788
11	56,212	*23,731*	79,943	27,955	*25,574*	53,529	17,044	*22,015*	39,059	7,913	*10,099*	18,012	19,720	*9,917*	29,637
12	63.2k	*24.8k*	88.0k	31.2k	*26,6k*	57.8k	17.7k	*24.4k*	42.1k	12.4k	*11.1k*	23.5k	23.6k	*11.4k*	34.9k

*** "k" = thousands**

*** Reach designations specified in Table 1a and mapped in Appendix A; Figure 2.**

Table 52. Estimated NUMBER of Juvenile Steelhead by AGE-CLASS and Reach in the San Lorenzo River Mainstem in 1997-2001, Using Habitat Proportions Based on Annual Habitat - Typing.

	1997			1998			1999			2000			2001		
*Reach**	YOY	Year-lings	Both Ages	YOY	Year-lings	Both Ages	YOY	Year-lings	Both Ages	YOY	Year-lings	Both Ages	YOY	Year-lings	Both Ages
0										141	84	225	181	225	406
1	5,201	181	5,382	3,604	175	3,779	5,060	1,056	6,116	305	492	797	1,521	139	1,660
2	5,455	499	5,954	5,888	443	6,331	1,456	258	1,714	826	203	1,029	1,938	114	2,052
3	4,679	280	4,959	2,905	220	3,125	2,521	373	2,894	2,582	362	2,944	2,129	524	2,653
4& 5	7,170	469	7,639	3,319	283	3,602	5,917	401	6,318	1,035	96	1,131	3,295	39	3,334
6	3,558	440	3,998	4,230	224	4,454	6,733	259	6,992	1,086	238	1,324	3,971	162	4,133
7	6,847	543	7,390	3,062	460	3,522	1,074	885	1,959	273	345	618	793	229	1,022
8	9,093	772	9,865	11,818	465	12,283	2,406	428	2,834	904	10	914	2,366	46	2,412
9	13,512	1,816	15,328	11,964	977	12,941	2,339	255	2,594	946	80	1,026	2,853	53	2,906
10	6,991	729	7,720	976	927	1,903	836	675	1,511	2,208	706	2,914	2,781	445	3,266
11	11,756	1,633	13,389	1,165	708	1,873	4,739	967	5,706	3,254	2,147	5,401	5,220	1,047	6,267
12	7,031	1,046	8,077	3,612	612	4,224	1,219	1,736	2,955	4,569	915	5,484	3,532	1,754	5,286

* Reach designations specified in Table 1a and mapped in Appendix A; Figure 2.

Table 53. Estimated NUMBER of Juvenile Steelhead in the Mainstem San Lorenzo River, ACCUMULATED by Reach in 1996-2000 in AGE CLASSES, using Habitat Proportions Determined by Habitat-Typing.

	1997		1998		1999		2000		2001	
Reach*	YOY	Year-lings	YOY	Year-lings	YOY	Year-lings	YOY	Year-lings	YOY	Year-lings
1	5,201	181	3,604	175	5,060	1,056	305	492	1,521	139
2	10,656	680	9,492	618	6,516	1,314	1,131	695	3,459	253
3	15,335	960	12,397	838	9,037	1,687	3,713	1,057	5,588	777
4&5	22,505	1,429	15,716	1,121	14,954	2,088	4,748	1,153	8,883	816
6	26,063	1,869	19,946	1,345	21,687	2,347	5,834	1,391	12,854	978
7	32,910	2,412	23,008	1,805	22,761	3,232	6,107	1,736	13,647	1,207
8	42,003	3,184	34,826	2,270	25,167	3,660	7,011	1,746	16,013	1,253
9	55,515	5,000	46,790	3,247	27,506	3,915	7,957	1,826	18,886	1,306
10	62,506	5,729	47,766	4,174	28,342	4,590	10,165	2,532	21,647	1,751
11	74,262	7,362	48,931	4,882	33,081	5,557	13,419	4,679	26,867	2,798
12	81,293	8,408	52,543	5,494	34,300	7,293	17,988	5,594	30,399	4,552

*** Reach designations specified in Table 1a and mapped in Appendix A; Figure 2.**

Table 54. Annual Comparisons of Estimated NUMBER of Juvenile Steelhead Produced by AGE CLASS in REACHES of the Mainstem San Lorenzo River (1997-2001), with 1999-2001 Tributary Production Included.

	1997			1998			1999			2000			2001		
Reaches*	YOY	Year-lings	Both Ages	YOY	Year-lings	Both Ages	YOY	Year-lings	Both Ages	YOY	Year-lings	Both Ages	YOY	Year-lings	Both Ages
1-5 Lower SLR (7.6 miles)	22.5k	1.4k	23.9k	15.7k	1.1k	16.8k	15.0k	2.1k	17.0k	4.9k	1.2k	6.2k	9.1k	1.0k	10.1k
6-9 Middle SLR (8.9 miles)	33.0k	3.6k	36.6k	31.1k	2.1k	33.2k	12,6k	1.8k	14.4k	3.2k	0.7k	3.9k	10.0k	0.5k	10.5k
10-12 Upper SLR (8.3 miles)	25.8k	3.4k	29.2k	5.8k	2.2k	8.0k	6.8k	3.4k	10.2k	10.0k	3.8k	13.8k	11.5k	3.3k	14.8k
1-12	81.3k	8.4k	89.70k	52.5k	5.5k	58.0k	34.3k	7.3k	41.6k	18.2k	5.7k	23.8k	30.6k	4.8k	35.4k
1-2 Branciforte 4.6 miles				14.8k	1.9k	16.6k	9.5k	3.1k	12.7k	11.3k	2.8k	14.1k	11.7k	2.0k	13.7k
1-2 Carbonera 3.4 miles				6.9k	0.6k	7.5k	5.0k	1.6k	6.5k	3.5k	2.0k	5.5k	4.1k	1.2k	5.3k
Branciforte Sub-Basin				21.6k	2.5k	24.1k	14.5k	4.7k	19.2k	14.8k	4.8k	19.6k	15.8k	3.2k	19.0k
1-4 Zayante (5.7 miles)				19.8k	1.7k	21.5k	22.0k	6.7k	28.6k	9.3k	3.7k	13.0k	15.1k	3.5k	18.6k
1-3 Bean (5.4 miles)				17.9k	1.5k	19.4k	6.1k	4.2k	10.3k	15.0k	2.3k	17.3k	8.3k	3.0k	11.2k
Zayante Creek Sub-Basin (without Lompico Cr.) (11.1 miles)				37.7k	3.2k	40.9k	28.1k	10.8k	39,0k	24.3k	6.0k	30.3k	23.4k	6.5k	29.8k
1 Fall (1.6 miles)				5.8k	0.5k	6.3k	5.8k	1.4k	7.2k	3.5k	0.7k	4.2k	3.9k	1.0k	4.9k
1 Newell (1.0 miles)				3.6k	0.4k	4.0k	1.0k	1.1k	2.2k	1.3k	0.4k	1.7k	2.0k	0.3k	2.3k
1-3 Boulder (3.5 miles)				13.4k	1.3k	14.7k	5.8k	3.1k	8.9k	5.3k	1.8k	7.1k	7.9k	1.9k	9.8k
1-2 Bear (4.7 miles)				18.1k	1.2k	19.3k	16.7k	5.5k	22.1k	8.3k	3.0k	11.3k	13.0k	2.9k	15.9k
1-2 Kings (3.7 miles)				3.3k	0.3k	3.6k	2.7k	1.2k	3.9k	3.8k	0.6k	4.4k	3.4k	1.3k	4.7k
Smaller Tribs. Combined (Fall, Newell, Boulder Bear and Kings)				44.2k	3.8k	48.0k	31.9k	12.3k	44.2k	22.2k	6.5k	28.7k	30.2k	7.4k	37.6k
TRIBUTARY SUBTOTAL				103.5K	9.5K	113.0K	74.5k	27.9k	102.5k	61.2k	17.3k	78.6k	69.4k	17.1k	86.4k
MAINSTEM AND TRIB.				156.1K	14.9K	171.0K	108.8k	35.2k	144.1k	79.8k	23.1k	103.0k	100.0k	21.9k	121.9k

*** Reach designations specified in Tables 1a-b and mapped in Appendix A; Figure 2.**

*** "k" = thousands.**

Table 55. Annual Comparisons of Estimated NUMBER of Juvenile Steelhead Produced by SIZE CLASS in REACHES of the Mainstem San Lorenzo River (1997-2001), with 1999-2001 Tributary Production Included. Reaches mapped in Appendix A.

	1997			1998			1999			2000			2001		
Reach*	SC#1	SC#2/3	All Sizes	SC#1	SC#2/3	All Sizes	SC#1	SC#2/3	All Sizes	SC#1	SC#2/3	All Sizes	SC#1	SC#2/3	All Sizes
1-5 Lower SLR (7.6 miles)	9.0k	14.4k	23.4k	2.1k	4.7k	16.8k	1.7k	15.9k	17.6k	1.0k	4.5k	5.5k	4.0k	6.4k	10.4k
6-9 Middle SLR (8.9 miles)	28.5k	7.0k	35.5k	24.3k	8.5k	32.7k	10.2k	4.3k	14.5k	1.8k	2.1k	3.9k	9.3k	1.4k	10.7k
10-12 Upper SLR (8.3 miles)	25.8k	3.4k	29.2k	4.8k	3.5k	8.3k	5.8k	3.9k	9.7k	9.6k	4.5k	14.1k	10.3k	3.9k	14.2k
1-12	63.2k	24.8k	88.0k	31.2k	26.6k	57.8k	17.6k	24.1k	41.7k	12.4k	11.1k	23.5k	23.6k	11.7k	35.3k
1-2 Branciforte Creek- Above Carbonera Confl. (4.6 miles)							9.5k	3.1k	12.7k	11.3k	2.8k	14.1k	11.7k	2.0k	13.7k
1-2 Carbonera Creek- to Moose Lodge Falls (3.4 miles)							4.9k	1.6k	6.5k	3.5k	2.0k	5.5k	4.1k	1.2k	5.3k
Branciforte Sub-Basin (8.0 miles)							14.4k	4.7k	19.1k	14.8k	4.8k	19.6k	15.8k	3.2k	19.0k
1-4 Zayante Creek- to Mt. Charlie Confl. (5.7 miles)							21.1k	7.5k	28.6k	7.9k	5.0k	12.8k	15.0k	3.5k	18.5k
1-3 Bean Creek- to Second Glenwood Rd Crossing (5.4 miles)							6.1k	4.2k	10.3k	14.9k	2.4k	17.3k	8.3k	2.9k	11.2k
Zayante Creek Sub-Basin (without Lompico Cr.) (11.1 miles)							27.2k	11.7k	38.9k	22.8k	7.4k	30.2k	23.3k	6.4k	29.7k
1 Fall Creek- to Boulder Falls (1.6 miles)							5.8k	1.4k	7.2k	3.5k	0.7k	4.2k	3.9k	1.0k	4.9k
1 Newell Creek- to Bedrock Falls (1.0 miles)							1.0k	1.1k	2.1k	1.1k	0.5k	1.6k	2.0k	0.3k	2.3k
1-3 Boulder Creek- to Bedrock Chute at Kings Highway (3.5 miles)							5.8k	3.1k	8.9k	5.3k	1.8k	7.2k	7.9k	1.9k	9.8k
1-2 Bear Creek- to Deer Creek Confl. (4.7 miles)							16.7k	5.5k	22.1k	7.7k	3.7k	11.5k	13.3k	2.6k	15.9k
1-2 Kings Creek- to Bedrock Cascade (3.7 miles)							2.7k	1.2k	3.9k	3.8k	0.6k	4.4k	3.7k	1.1k	4.8k
Smaller Tributaries Combined (Fall, Newell, Boulder, Bear and Kings)							31.9k	12.3k	44.2k	21.5k	7.4k	28.8k	30.8k	6.7k	37.5k
TRIBUTARY SUBTOTAL							73.6k	28.7k	102.3k	59.1k	19.5k	78.7k	69.9k	16.5k	86.4k
MAINSTEM AND TRIBUTARY TOTAL							91.2k	52.8k	144.0k	71.5k	30.6k	102.2k	93.5k	28.2k	121.7k

Table 56. Estimated Number of Juvenile Steelhead by SIZE-CLASS in the San Lorenzo River Mainstem From Highway 1 to Above Waterman Gap in Fall of 1981, 1994-2001, with Tributary Estimates Included in 1998-2001.

YEAR	# OF SIZE-CLASS 1 STEELHEAD (< 75 mm SL)	# OF SIZE-CLASSES 2 & 3 STEELHEAD (=> 75 mm SL)	TOTAL NUMBER OF JUVENILES
1981 Mainstem	37,000*	31,500	69,000
1994 Mainstem	24,500	23,000	45,000
1995 Mainstem	37,000	38,000	75,000
1996 Mainstem	40,000	32,500	72,500
1997 Mainstem	63,000	25,000	88,000
1998 Mainstem	31,000	26,000	58,000
1999 Mainstem	17,500	24,000	41,500
2000 Mainstem	12,500	11,000	23,500
2001 Maintsem	23,500	11,500	35,000
1998 Tribs.	91,500	19,000	111,000
1999 Tribs.	73,500	28,500	102,000
2000 Tribs.	59,000	19,500	78,500
2001 Tribs.	70,000	16,500	86,500
1998 TOTAL	123,000	45,500	168,500
1999 TOTAL	91,000	53,000	144,000
2000 TOTAL	72,000	30,500	102,500
2001 TOTAL	93,500	28,000	121,500

Prior to 1996, estimates came from sampling site densities extrapolated to reach densities. In 1997, estimates came from habitat-type densities extrapolated to reach densities after habitat proportioning was determined. A revised 1996 estimate was generated, using 1997 habitat proportions. In 1998-2001, habitat proportions were annually determined. Estimates are approximate and rounded to the nearest 500.

57. Estimated Number of Juvenile Steelhead by AGE-CLASS in the San Lorenzo River Mainstem From Highway 1 to Above Waterman Gap in Fall of 1996-2000, with 1998-2000 Tributary Estimates Included.

YEAR	# OF YOUNG-OF-THE-YEAR STEELHEAD	# OF YEARLING STEELHEAD	TOTAL NUMBER OF JUVENILES
1996 Mainstem	62,000*	9,500*	71,500*
1997 Mainstem	81,500	8,500	89,500
1998 Mainstem	52,500	5,500	58,000
1999 Mainstem	34,500	7,500	41,500
2000 Mainstem	18,000	5,500	24,000
2001 Mainstem	30,500	5,000	35,500
1998 Tribs.	103,500	9,500	113,000
1999 Tribs.	74,500	28,000	102,500
2000 Tribs.	61,000	17,500	78,500
2001 Tribs.	69,500	17,000	86,500
1998 TOTAL	156,000	15,000	171,000
1999 TOTAL	109,000	35,000	144,000
2000 TOTAL	79,500	23,000	102,500
2001 TOTAL	100,000	22,000	122,000

* Estimates were rounded to the nearest 500. Estimates for all juveniles combined differed when combining age classes versus size classes because density estimates at sampling sites were determined separately by age and size.

Fish Population Monitoring- Tributaries

Overall Summary

In 1998-2001, the 9 sampled tributaries produced an estimated 113,000, 102,500, 78,600 and 86,400 juvenile steelhead, respectively, accounting for approximately 66%, 71%, 77% and 71% of the River system's juvenile populations (**Table 54**). In comparing 2001 to 2000, the tributary production of juveniles was up 10% in 2001. The entire watershed's juvenile production was up 18%. Zayante Creek was the most productive in 2001 for YOY's, with Bear, Branciforte, Bean and Boulder being, second, third and fourth (**Table 54**). The four largest contributors to yearling numbers in tributaries in descending order were Zayante, Bean, Branciforte and Bear creeks. Tributaries that increased by 30% for yearlings in 2001 were Bean, Fall and Kings creeks. The other tributaries had similar numbers in both years. Regarding production of larger juveniles (=>75 mm SL), the four largest contributors in declining order were Zayante, Bean, Bear and Branciforte creeks (**Table 55**).

In 2001 tributaries produced 75% of the Size Class 1 juveniles (83% in 2000, 80% in 1999), 69% of YOY fish (77% in 2000, 68% in 1999), 58% of the Size Class 2 and 3 juveniles (61% in 2000 and 54% in 1999) and 78% of the yearlings (75% in 2000, 79% in 1999) (**Tables 54 and 55**).

Tabular and Graphical Representation for Tributary Fish Densities

Figure 2 summarizes site densities of size classes for tributaries. **Figures 3 and 4** provide size class densities in 1997-2001 at comparable sites. **Tables 1a-c of reach and site descriptions are repeated on pages 131-134 before the Figures.** **Figure 5** provides average tributary site densities where historical data are available. **Table 58 and Figure 7** summarize site densities of age classes. **Figures 8 and 9** provide age class densities at comparable sites in 1997-2001. **Table 59** provides average site densities by age class for tributary sites. **Tables 60 and 61** summarize reach densities for size classes and age classes. **Tables 56 and 57** provide size and age class totals for combined tributary reaches. **Figures 19-21** provide production estimates by tributary for year classes and all juveniles for 1998-2001.

Densities and Production of Steelhead in the Young-of-the-Year Age Class- Tributaries

Out of the 20 tributary sites in 2001, 15 of 20 increased in YOY density (one only slightly) compared to 2000, but only 7 of 20 increased (one only slightly) compared to 1999 (**Table 58**). YOY densities were essentially synonymous with the Size Class 1 densities. Average site densities for tributaries increased in 6 of 9 tributaries in 2001 (**Table 59**). Site densities that did not increase in 2001 were in upper Bean (14c), upper Bear (18b), lower and upper Kings (19a and b) and lower Branciforte (21a), although the site on upper Bean had to be moved back to the 1999 site because the 2000 site was dry. When looking at comparable sites through the years, the 2001 site densities were still considerably less than in 1997 or 1998 levels at many sites (**Figure 8**).

The relative differences in reach densities for YOY fish in 2001 and 2000 were the same as for Size Class 1 densities (**Table 61**). Therefore, 15 of 20 reaches showed increased YOY and Size Class 1 densities in 2001. Reach densities of Size Class 1 fish increased in all reaches of Zayante, Fall, Newell, Boulder Bear creeks (**Table 60**). Kings Creek was similar in 2000 and 2001, but slightly lower in 2001. Bean Creek's upper reach was lower in 2001 but not directly comparable to 2000 because some of it was dry in 2001, and the sites were different between years. Streamflow resurfaced a short distance above the 2000 site in upper Bean Creek. Carbonera and Branciforte creeks had one reach each with lower density in 2001, but the overall stream density was slightly higher in 2001.

Production estimates for YOY juveniles in 2001 indicated increases in 7 of 9 tributaries compared to

2000, especially in Zayante and Bear creeks (**Table 54; Figure 19**). The 2001 tributary production estimate was 30,200 compared to 22,200 in 2000. However, it was slightly less than the 31,900 estimated for 1999 and was far less than the 103,600 estimated in 1998.

Densities and Production of Steelhead =>75 mm Standard Length and the Yearling Age Class in Tributaries

Comparisons of reach densities of yearlings between 2000 and 2001 paralleled those of larger juvenile size classes (**Table 61**). Looking at tributary production of yearlings, those that noticeably increased in 2001 were Bean, Fall and Kings creeks (**Table 54; Figure 20**). Branciforte and Carbonera creeks had sizeable declines. Other tributaries had similar yearling densities between years. The number of yearlings produced in the tributaries was similar in 2001 (17,100) as in 2000 (17,300) (**Table 54 and 57**).

Densities of fish =>75 mm SL declined at 13 of 20 sites in 2001 (**Table 58**). The largest declines came in the lower 3 reaches of Zayante Creek, Newell Creek, lower Bear and lower Branciforte creeks and upper Carbonera. The largest increases occurred in upper Kings and upper Bear creeks. Average site densities declined in 5 of 9 tributaries (**Table 59**). Reach densities of Size Classes 2 and 3 fish declined in most reaches of the Zayante-Bean and Branciforte-Carbonera sub-basins, along with Newell, lower Boulder and lower Bear (**Table 60**). Large increases in reach densities of larger juveniles occurred in middle Boulder, upper Bear and upper Kings creeks. Other reaches were similar between the two years. Zayante and Bear creeks had notably fewer Size Class 2 and 3 juveniles in 2001 due to slower growth rate, and Branciforte had fewer, as well (**Table 55**). The number of larger juveniles produced in tributaries was less in 2001 (16,300 compared to 19,500 in 2000) (**Table 55 and 56**). This was likely because there were fewer YOY from 2000 to be recruited as yearlings, growth rate was reduced due to reduced streamflow and perhaps there was reduced rearing habitat for larger juveniles in some tributaries with less streamflow than in 2000.

Total Density of Juvenile Steelhead in Tributary Reaches of the San Lorenzo River Drainage.

In 2001, overall density of juveniles declined slightly for the Zayante (including Bean) and Branciforte (including Carbonera) sub-basins compared to 2000, largely due to reduced yearling densities (**Table 60**). Total densities in other tributaries increased in 2001, largely due to increased YOY production. Tributary production of juveniles increased notably in 2001 in Zayante, Boulder and Bear creeks with more YOY's (**Table 55; Figure 21**). Estimated total numbers declined most in Bean Creek in 2001, though differences between years were somewhat vague because portions of upper Bean Creek went dry in 2001 that were watered in 2000. The overall juvenile production in 2001 was greater than in 2000, but less than 1998 and 1999 (**Table 56**).

Long-term Trends in Tributary Site Densities of All Juveniles

Average site densities for all juveniles in Zayante, Bean and Fall creeks improved in 2001 over 2000 for Fall and Zayante creeks, but densities in these creeks were less than they were in 1997-99 (**Figure 5**). Densities in 2001 in the three tributaries were above densities found during the dry years of 1989 and 1994. Data for 1970 came from unpublished CDFG data. Data for 1981 came from county-wide sampling (**Smith 1982**). Data for 1989 came from EIR work done to assess impacts of proposed wells (**Gilchrist 1990**). Recent data were from the present monitoring program (**Alley 1995-2001**). More detailed density measurements were included in last year's monitoring report (**Alley 2001**).

Table 58. DENSITY of Juvenile Steelhead by AGE CLASS at MONITORING SITES in Tributaries of the San Lorenzo River in 1997-2001.

Sampling Site *	Site No.	Juvenile Densities** Y-O-Y's 1997	1998	1999	2000	2001	Yearlings and 2+ 1997	1998	1999	2000	2001
Zayante Creek	#13a		80.0	96.4	29.0	52.9		3.0	7.6	17.7	1.9
Zayante Creek	#13b	64.9	43.5	60.6	7.7	31.2	10.0	7.2	14.3	17.2	6.8
Zayante Creek	#13c		66.9	50.2	9.4	30.9		2.1	11.7	16.4	9.1
Zayante Creek	#13d		77.4	77.7	41.9	67.0		4.7	27.3	15.6	17.1
Bean Creek	#14a		43.4	42.0	11.1	36.0		0.8	39.4	5.9	2.0
Bean Creek	#14b	0.7	104.3	59.0	41.3	60.2	12.3	11.3	33.1	7.0	5.3
Bean Creek	#14c		71.8	6.9	76.6	18.1		6.4	15.8	10.9	18.7
Fall Creek	#15	79.6	74.8	68.1	45.1	45.4	4.9	7.9	16.9	9.9	14.4
Newell Creek	#16	77.1	67.6	17.7	19.9	35.6	17.8	8.7	22.8	8.9	4.7
Boulder Creek	#17a	119.2	141.5	50.7	22.9	55.9	15.0	7.7	17.8	9.1	5.2
Boulder Creek	#17b	91.8	68.0	36.2	33.9	38.9	8.9	6.9	13.3	9.1	12.9
Boulder Creek	#17c		37.6	15.3	27.5	30.7		5.2	18.6	8.5	8.7
Bear Creek	#18a	100.2	72.4	57.9	12.6	50.8	18.3	7.8	18.1	21.0	8.0
Bear Creek	#18b		66.6	89.2	58.3	48.1	18.3	2.9	26.9	9.3	15.4
Kings Creek	#19a		9.8	0	6.6	6.0		1.0	0.5	1.8	1.6
Kings Creek	#19b	48.2	20.8	32.1	31.5	28.5	4.5	2.1	12.8	6.0	13.1
Carbonera Creek	#20a	9.1	17.2	13.2	5.6	16.5	4.3	3.8	5.7	4.1	3.1
Carbonera Creek	#20b		50.9	40.3	29.7	33.4		2.5	11.4	15.5	11.8
Branciforte Crk	#21a	64.6	54.1	35.5	47.2	34.2	5.4	6.1	11.6	18.0	11.0
Branciforte Crk	#21b		60.1	44.2	45.8	49.4		7.6	13.4	11.1	8.1

* Refer to Table 1c for Site description and Appendix A- Figure 2 for Locations.

** Density in number of fish per 100 feet of stream.

Table 59. Average Site Density per Creek for Juvenile Steelhead by AGE-CLASS in Tributaries of the San Lorenzo River in 1998-2001.

Year/ Age Class	Branci-forte	Carbo-nera	Zayan-te	Bean	Fall	Newell	Boulder	Bear	Kings
	Average Site Density per Creek- 1998-2001* (Standard Deviation)								
1998/ Y-O-Y	57.1 (3.0)	34.1 (16.9)	67.0 (14.4)	73.2 (24.9)	74.8 NA**	67.6 NA	82.4 (43.6)	69.5 (2.9)	15.3 (5.5)
1999/ Y-O-Y	39.1 (4.4)	26.8 (13.6)	71.2 (17.5)	56.9 (11.4)	68.1 NA**	17.7 NA	34.1 (14.5)	73.6 (15.7)	16.1 (16.1)
2000/ Y-O-Y	46.5 (0.7)	17.7 (12.1)	22.0 (14.2)	43.0 (26.8)	45.1 NA**	19.9 NA	28.1 (4.5)	35.5 (22.9)	19.1 (12.5)
2001/ Y-O-Y	41.8 (7.6)	25.0 (8.5)	45.5 (15.3)	38.1 (17.3)	45.4 NA	35.6 NA	41.8 (10.5)	49.5 (1.4)	17.3 (11.3)
1998/ Year-lings	6.9 (0.8)	3.2 (0.7)	4.3 (1.9)	6.2 (4.3)	7.9 NA	8.7 NA	6.6 (1.0)	5.4 (2.5)	1.6 (0.6)
1999/ Year-lings	12.5 (0.9)	8.6 (2.9)	15.2 (7.4)	29.4 (10.0)	16.9 NA	22.8 NA	16.6 (2.3)	22.5 (4.4)	6.7 (6.2)
2000/ Year-lings	14.6 (3.5)	9.8 (5.7)	16.7 (0.8)	7.9 (2.1)	9.9 NA	8.9 NA	8.9 (0.3)	15.2 (5.9)	3.9 (2.1)
2001/ Year-lings	9.6 (1.5)	7.5 (4.4)	8.7 (5.5)	8.7 (7.2)	14.4 NA	4.7 NA	8.9 (3.1)	11.7 (3.7)	7.4 (5.8)

*** Density measured as number of steelhead per 100 feet of stream.**

**** Not applicable because only one site was sampled in the Creek.**

Table 60. Comparisons of Estimated REACH DENSITY (fish/ 100 ft) of Juvenile Steelhead Produced by SIZE-CLASS in Tributary REACHES of the San Lorenzo River, 1998-2001.

	1998			1999			2000			2001		
Tributary Sub-Basin	<75mm SL	=>75mm SL	All Sizes	<75mm SL	=>75mm SL	All Sizes	<75mm SL	=>75mm SL	All Sizes	<75mm SL	=>75mm SL	All Sizes
21a-b Branci-	53.3	13.5	66.8	39.2	12.9	52.9	46.3	11.6	57.9	47.9	8.1	56.0
21a forte	56.1	11.9	68.0	21.4	7.6	29.0	46.5	12.3	58.8	40.4	9.9	50.3
21b	51.2	14.7	65.9	51.9	16.8	68.7	46.1	11.1	57.2	53.6	7.0	60.6
20a-b Carbo-nera	27.9	13.8	41.7	27.3	8.8	36.1	19.8	10.9	30.7	22.7	6.9	29.6
20a	9.2	11.5	20.8	11.5	5.1	16.6	5.8	4.0	9.8	16.6	2.7	19.3
20b	40.7	15.3	56.0	38.1	11.3	49.4	29.4	15.6	45.0	26.8	9.8	36.6
Branciforte Sub-Basin	43.4	13.6	57.0	34.1	11.2	45.3	36.1	11.6	47.7	37.4	7.6	45.0
13a-d Zayante	59.2	12.6	71.8	69.9	24.9	94.8	26.3	16.5	42.8	49.7	11.7	61.4
13a	73.8	12.9	86.7	91.2	13.7	104.9	11.7	16.1	27.8	50.9	1.6	52.5
13b	34.2	15.2	49.4	52.6	24.1	76.7	8.0	16.7	24.7	28.7	7.5	36.2
13c	57.8	12.8	70.6	45.8	19.6	65.4	8.6	16.0	24.6	53.3	9.8	63.1
13d	73.5	10.6	84.1	82.9	29.4	112.3	46.8	16.6	63.4	63.2	17.5	80.7
14a-c Bean	71.7	6.3	78.1	24.8	16.8	41.6	51.9	8.3	60.2	29.0	10.2	39.2
14a	48.7	3.0	51.7	41.3	3.8	45.1	13.6	6.6	20.2	40.4	1.5	41.9
14b	103.7	11.1	114.8	52.8	29.4	82.2	33.9	5.7	39.6	53.1	4.5	57.6
14c	72.1	6.4	78.6	6.9	18.1	25.0	70.2	9.7	79.9	18.1	15.1	33.2
Zayante Sub-Basin (without Lompico Cr.)	64.8	9.8	71.0	49.6	21.3	70.9	38.7	12.5	51.2	39.6	11.0	50.6
15 Fall	63.4	12.4	75.8	69.5	17.0	86.5	41.8	8.5	50.3	47.0	10.2	57.2
16 Newell	59.1	13.2	72.3	17.7	23.2	40.9	20.7	8.7	29.4	35.7	5.1	40.8
17a-c Boulder	54.9	12.3	67.2	31.7	16.8	48.5	29.2	9.9	39.1	43.2	10.4	53.6
17a	127.7	23.5	151.2	46.5	15.5	62.0	25.4	12.5	37.9	66.1	6.7	72.8
17b	64.0	13.0	77.1	43.5	15.0	58.5	32.1	8.3	40.4	39.2	13.2	52.4
17c	38.7	5.2	43.9	19.3	18.9	38.2	29.1	9.7	38.8	33.1	10.5	43.6
18a-b Bear	69.4	9.0	78.4	67.3	22.1	89.4	31.2	15.1	46.3	53.8	10.4	64.2
18a	73.4	12.0	85.4	51.9	18.8	70.7	12.1	21.4	33.5	52.9	7.7	60.6
18b	65.0	6.0	71.0	83.7	25.5	109.2	51.6	8.3	59.9	54.9	13.2	68.1
19a-b Kings	10.0	8.8	18.8	13.7	6.1	19.8	19.2	3.1	22.3	18.8	5.5	24.3
19a	7.0	8.0	15.0	0	0.5	0.5	6.5	1.8	8.3	6.2	2.0	8.2
19b	13.6	9.7	23.3	30.3	12.9	43.2	34.5	4.9	39.4	34.4	9.8	44.1

Table 61. Comparisons of Estimated REACH DENSITY (fish/ 100 ft) of Juvenile Steelhead by AGE-CLASS in TRIBUTARY REACHES of the San Lorenzo River, 1998-2001.

	1998			1999			2000			2001		
Tributary Sub-Basin	YOY	Year-lings	Both Ages	YOY	Year-lings	Both Ages	YOY	Year-lings	Both Ages	YOY	Year-lings	Both Ages
21a-b Branci-	60.6	7.8	68.4	39.2	12.9	52.9	46.2	11.6	57.8	48.1	8.2	56.3
21a forte	60.4	8.4	68.8	21.4	7.6	29.0	46.5	12.3	58.8	40.3	10.0	50.3
21b	60.8	7.3	68.1	51.9	16.8	68.7	46.1	11.1	57.2	53.6	7.0	60.6
20a-b Carbo-	38.4	3.2	41.6	27.3	8.8	36.1	21.7	10.9	32.6	22.7	6.9	29.6
20a nera	16.6	3.8	20.4	11.5	5.1	16.6	5.8	4.0	9.8	16.6	2.7	19.3
20b	53.0	2.7	55.7	38.1	11.3	49.4	29.4	15.6	45.0	26.8	9.8	36.6
Branciforte Sub-Basin	51.2	5.8	57.0	34.1	11.2	45.3	35.0	11.3	46.3	37.4	7.6	45.0
13a-d Zayante	65.6	5.6	71.3	72.8	22.1	94.9	30.6	12.3	42.9	49.9	11.6	61.5
13a	84.1	3.0	87.0	97.7	7.4	105.1	24.2	3.7	27.9	50.9	1.6	52.5
13b	35.3	7.5	42.8	57.4	19.2	76.6	14.6	10.3	24.9	28.9	7.2	36.1
13c	65.7	1.9	67.6	52.0	13.9	65.9	16.5	8.6	25.1	53.7	9.4	63.1
13d	80.1	5.4	85.5	83.0	29.5	112.5	46.8	16.6	63.4	63.2	17.5	80.7
14a-c Bean	72.2	5.9	78.1	24.8	16.8	41.6	59.1	8.3	60.2	28.7	10.2	38.9
14a	49.0	1.1	50.1	41.3	3.8	45.1	13.6	6.6	20.2	40.4	1.5	41.9
14b	103.7	11.1	114.8	52.8	29.4	82.2	33.9	5.7	39.6	53.1	4.5	57.6
14c	72.1	6.4	78.5	6.9	18.9	25.8	70.2	9.7	79.9	18.1	15.1	33.2
Zayante Sub-Basin (without Lompico Cr.)	68.6	5.8	74.4	51.2	19.7	70.9	41.1	10.2	51.3	39.5	10.9	50.4
15 Fall	69.6	6.4	76.0	69.5	17.0	86.5	41.8	8.5	50.3	46.6	11.5	58.1
16 Newell	66.2	7.5	73.7	17.7	23.2	40.9	23.5	7.5	31.0	35.7	5.1	40.8
17a-c Boulder	73.5	7.1	80.6	31.7	16.8	48.5	39.9	12.5	52.4	43.2	10.4	53.6
17a	143.0	6.9	149.9	46.5	15.5	62.0	25.5	12.5	38.0	66.1	6.7	72.8
17b	66.3	9.5	75.8	43.5	15.0	58.5	32.1	8.3	40.4	39.2	13.2	52.4
17c	40.2	5.4	45.6	19.3	18.9	38.2	29.1	9.3	38.4	33.1	10.5	43.6
18a-b Bear	73.0	5.0	78.0	67.3	22.1	89.4	33.4	12.1	45.5	52.3	11.6	63.9
18a	78.3	7.0	85.3	51.9	18.8	70.7	16.2	15.8	32.0	52.9	7.7	60.6
18b	67.4	2.8	70.2	83.7	25.5	109.2	51.7	8.2	59.9	51.7	15.8	67.5
19a-b Kings	16.7	1.7	18.4	13.7	6.1	19.8	19.2	3.2	22.4	17.5	6.7	24.2
19a	13.3	1.3	14.6	0	0.5	0.5	6.5	1.8	8.3	6.2	2.2	8.2
19b	20.9	2.1	23.0	30.3	12.9	43.2	34.5	4.8	39.3	31.1	12.4	43.5

Estimated Index of Adult Returns

Using Dettman's Waddell Creek model (**Kelley and Dettman 1987**) of Waddell Creek return data (**Shapovalov and Taft 1954**) and the 50% correction factor based on Smith's (**1992**) work, indices of returning adults were calculated from estimated mainstem juveniles only, prior to 1998. Adult estimates prior to 1997 were generated from juvenile densities at sampling sites that were extrapolated to reach densities. A revised adult estimate for 1996 was generated, using habitat proportions found in 1997 habitat-typing. From 1998 to the present, juvenile production has been estimated from more extensive juvenile sampling and habitat typing in the 9 major tributaries besides the mainstem, allowing adult return indices based on most of the watershed's juveniles. The 2001 estimates of juvenile densities were derived using habitat proportions in 2000.

The index of adults expected from mainstem juveniles declined for 1995-2000 and increased slightly in 2001 (**Tables 62 and 63; Figure 22**). The tributary index of adults in 2001 was the lowest in 4 years, leading to the lowest watershed index in the 4 years that we have estimates. A sharp decline in juvenile production the mainstem and tributaries in 2000 had resulted in a concomitant reduction in the adult index. Although YOY production was up in 2001 production of yearlings and juveniles in Size Classes 2 and 3 were less than in 2000. This lead to a slight overall decline in the watershed adult index because it is the larger juveniles that most contribute to the adult index with their higher survival rate. Juvenile growth into the larger size classes was reduced primarily due to reduced streamflow. There were fewer yearlings in 2001 due probably to the drop in YOY's the previous year and reduced rearing habitat in 2001 under reduced streamflow.

In comparing 2001 to 2000 in the mainstem, the lower River contributed more to the adult index in 2001, and the upper River contributed less (**Table 62**). **Indices from juveniles for 1998-2001 were 1,300, 1,150, 560 and 610 adults, respectively, representing a 9% increase from 2000 to 2001 (Table 63).** The proportion of adults expected from mainstem juveniles in 1998-2001 was 52%, 43%, 35% and 38%, respectively, indicating a diminished mainstem contribution.

Adult indices from tributary juveniles from 1998-2001 was 1,200, 1,500, 1,070 and 980, respectively, representing a 9% decline. The largest decline in contribution to the adult index in tributaries in 2001 came from Branciforte, Carbonera, Zayante and Bear creeks. In looking at the relative contributions of tributaries to the adult index, the Zayante and Bean sub-watershed continued to be the most important, followed by the Branciforte-Carbonera sub-watershed, Bear and Boulder creeks. Adults expected from tributary juveniles in 2001 included 23.5% from the Zayante sub-basin (25% in 2000, 23% in 1999; 15% in 1998), 12.5% from the Branciforte sub-basin (16% in 2000, 10% in 1999; 13% in 1998), 10% from Bear Creek (12% in 2000, 11% in 1999, 6.5% in 1998), and 7% from Boulder Creek (6% in 1998-2000) (**Table 61**). Juveniles combined from Fall, Newell and Kings creeks contributed 8% to the adult index in 2001 (6% in 2000, 8% in 1998 and 1999). **Adult indices from mainstem and tributary juveniles for 1998-2001 were 2,470, 2,670, 1,640 and 1,580 adults (Table 62).**

Table 62. Comparisons of Estimated INDEX of Adults Returning from Juveniles Produced by

SIZE CLASS in Segments of the Mainstem San Lorenzo River (1996-2001), with 1998-2001 Tributary Production Included.

Mainstem Reaches* and 7 Tributary Sub-Basins (57.7 channel miles)	1996	1997	1998 (% Adult Return)	1999 (% Adult Return)	2000 (% Adult Return)	2001 (% Adult Return)	% Channel Miles
1-5 Lower SLR (7.6 miles)	1,540	652	646 (26,2%)	710 (26.6%)	232 (14.2%)	301 (19.0%)	13%
6-9 Middle SLR (8.9 miles)	492	420	460 (18.6%)	228 (8.5%)	99 (6.1%)	97 (6.1%)	15%
10-12 Upper SLR (8.3 miles)	277	242	178 (7.2%)	212 (7.9%)	234 (14.3%)	209 (13.2%)	14%
1-12 Mainstem SLR (24.8 miles)	2,309	1,314	1,284 (52%)	1,150 (43%)	565 (35%)	607 (38%)	43%
1-2 Branciforte Creek			193(7.8%)	171(6.4%)	165(10.1%)	130(8.2%)	
1-2 Carbonera Creek			125(5.1%)	86(3.2%)	97(5.9%)	68(4.3%)	
Branciforte Sub-Basin			318(12.9%)	257(9.6%)	262 (16.0%)	198(12.5%)	14%
1-4 Zayante Creek			230(9.3%)	401(15.0%)	248(15.2%)	214(13.5%)	
1-3 Bean Creek			136(5.5%)	204(7.6%)	159(9.7%)	158(10.0%)	
Zayante Creek Sub-Basin (without Lompico Cr.)			366(14.8%)	605(22.6%)	407(24.9%)	372(23.5%)	18%
1 Fall Creek			64(2.5%)	83(3.1%)	44(2.7%)	52(3.3%)	2.7%
1 Newell Creek			45(1.8%)	62(2.3%)	25(1.5%)	20(1.3%)	1.8%
1-3 Boulder Creek			146(5.9%)	156(5.8%)	102(6.2%)	115(7.3%)	6.1%
1-2 Bear Creek			162(6.5%)	297(11.1%)	189(11.6%)	159(10.0%)	8.1%
1-2 Kings Creek			83(3.4%)	62(2.3%)	42(2.6%)	60(3.8%)	6.5%
Smaller Tributaries Combined			500(20.2%)	660(24.7%)	402(24.6%)	406(25.6%)	25.2%
Tributary Adult Index			1,184(48%)	1,522(57%)	1,071(65%)	976(62%)	
Watershed Adult Index			2,468	2,669	1,636	1,583	

Table 63. Adult Index of Steelhead Returns to the San Lorenzo River in 1981 and 1994-2001, Including Nine Tributaries in 1998-2001, Using Dettman's Model (Kelley and Dettman 1987).

SAMPLE YEAR	NUMBER OF FIRST TIME SPAWNERS	TOTAL NUMBER OF RETURNING ADULTS
1981 Mainstem	1,250	1,500
1994 Mainstem	900	1,100
1995 Mainstem	1,500	1,800
1996 Mainstem	1,300	1,500
1997 Mainstem	1,100	1,300
1998 Mainstem	1,100	1,300
1999 Mainstem	950	1,150
2000 Mainstem	450	550
2001 Mainstem	500	610
1998 Tribs.	1,000	1,200
1999 Tribs.	1,300	1,500
2000 Tribs.	900	1,100
2001 Tribs.	800	1,000
1998 Mainstem + Tribs.	2,100	2,500
1999 Mainstem + Tribs.	2,250	2,650
2000 Mainstem + Tribs.	1,350	1,650
2001 Mainstem + Tribs.	1,300	1,600

* Assumes 20% repeat spawners. Estimates Include a 50% Reduction Factor Applied to Modeling Results, Based on Smith's 1991-92 Estimate of Adult Returns to Waddell Creek.

Estimates of Adult Returns Based on Recent Trapping Data at the Felton Diversion Dam

Historical data available on trapping of adult steelhead on the San Lorenzo River have been summarized (**Table 64**) for comparison with our indices of adult returns. Trapping numbers between the earlier years and more recent years are not directly comparable because egg-taking stations in the 1930's and 1940's were on the mainstem in Brookdale and Boulder Creek above several tributaries (**Appendix A**) and we do not know the duration of trapping each year. Some spawners went up these tributaries or spawned in the mainstem below the egg-taking stations in the past. The largest downstream tributary, Zayante Creek, has been estimated to contain 18% of the salmon and steelhead habitat in the San Lorenzo Drainage (Ricker and Butler 1979) and coincidentally constituted 18% of the channel miles assumed to be inhabited by steelhead in our annual monitoring (**Table 62**). The juvenile populations in Zayante Creek sub-basin have contributed between 15% and 25% to the watershed adult index in the last 4 years (**Table 62**).

The trap at the Felton Diversion Dam is below the Zayante Creek confluence (**Appendix A**), but upstream of 5 of the 6 lower River reaches and the Branciforte sub-watershed. Adults spawn in the Gorge and Paradise Park, with juveniles from the lower River contributing to 19% of the index of adult returns from 2001 juveniles (301 adults). The Branciforte sub-watershed would contribute to another 12.5% of the adult returns from 2001 juveniles (198 adults). The Felton trap is inoperative during stormflows that force the dam to be deflated or at other times when the dam is not needed for diversion. The fish ladder is not used by adult steelhead when the dam is deflated, and no trapping is done when the dam is deflated. However, in 2000 and 2001 the City of Santa Cruz left the dam inflated as much as possible to aid in the trapping operation used for obtaining broodstock for the hatchery and in measuring the number steelhead passing the dam. Even so, trapping data under-estimates the number of adults to some degree and serves as an index of adult returns. The trap is more effective in drier years without major storms, such as 1976, 1977 and 2001, and less effective during a wet year such as 1998 or a year with 4-5 flashy peak flows, such as 2000. In 2000, 532 adult steelhead were trapped at the Felton diversion dam from 17 January to 10 April (85 days). In 2001, the total was 538 adults trapped from about 12 February to 20 March (37 days).

The Felton Diversion Dam may cause passage difficulties at certain streamflows. Difficulty in locating the fish ladder when streamflow is spilling over the inflatable dam may be a problem at intermediate flows when fish cannot jump over the dam. A Memorandum of Agreement was signed by the Department of Fish and Game and the City of Santa Cruz in 1996 to alter the dam operation to improve fish passage. Under the new operating procedures, when the dam is deflated and the flow is less than 40 cfs, air bladders are used to focus water to the center of the dam. When the dam is inflated and flows are greater than 300 cfs, a slide gate is opened 8 inches to allow for fish passage. When streamflow is greater than 300 cfs for more than 5 days in a row and the dam is inflated, the dam is partially deflated to 4 feet and the slide gate is closed overnight. The dam may then be re-inflated the next morning as needed (Entrix 1997). Without a consistent steelhead trapping or monitoring program at the dam, the effectiveness of these measures is unclear.

By assuming that the primary spawning season in each year constituted the time between the first major storm (greater than 100 cfs mean daily flow at the Big Trees Gage) after December 1 and the last storm of the season (until stormflow declines below 100 cfs at the Big Trees Gage), then we can estimate the length of the spawning season. The streamflow of 100 cfs was used as the cut-off because we have estimated in the past that adult steelhead may have difficulty in reaching the trap when streamflows are less than 100 cfs, based on the first appearance of adult steelhead at the Felton Diversion Dam in the drought year of 1991. By assuming that the rate of capture at the trap during the time it was operating was equal to the rate at which adults passed the trap when it was not operating, then we may estimate the total number of adults that may have passed the location of the trap in each year. Then by assuming that the spawning effort downstream of the trap was proportional to the proportion of the adult index that juveniles contributed to the index from the watershed downstream of the trap, we can estimate the number of adults that spawned downstream of the trap. This may be an overestimate because some of the juveniles that reared in the lower River were likely spawned upstream of the trap location.

In 2000, the estimated spawning season was 10 January to 18 April consisting of 100 days. A total of 532 adult steelhead were trapped in 85 days. Therefore, an estimated 626 adults passed the trap during the primary spawning season. In 2000, 487 adults of the total watershed index of 1,636 were contributed by juveniles below the trap, constituting 30%. Therefore, 626 adults constituted an estimated 70% of the 2000 adult run, making 894 the estimated adult run for 2000. Rounded to the nearest 50, the adult estimate would be 900 adults for the primary spawning period. It should be noted that adults could avoid the fish ladder and trap during larger stormflows. In 2001, the estimated spawning season was 12 January to 22 April consisting of 101 days. A total of 538 adult steelhead were trapped in 38 days (38% of the estimated spawning season), 140 (26%) being from hatchery smolts. Therefore, an estimated 1,430 adults passed the trap during the primary spawning season. In 2001, an estimated 470 of the 1,583 adult index were from juveniles produced below the trap, constituting 30% of the total adult index. Therefore, the 1,430 adults estimated to pass the Felton dam constituted 70% of the 2001 adult run, making 2,043 the estimated adult run for 2001. Rounded to the nearest 50, the adult estimate would be 2,050 for the primary spawning period. Using the percentage of hatchery origin adults to wild adults captured at the trap (26%) as an estimate of the ratio in the overall adult estimate, an estimate of 1,511 adults were wild adults from natural production. This 1,511 estimate was less than the adult index of 2,500 that was generated from juvenile population estimates from 1998 juveniles and the Dettman (1987) model.

Table 64. Historical Adult Steelhead Trapping Data from the San Lorenzo River With Recent Estimates of Adult Returns.

Trapping Year	Trapping Period	Number of Adults	Location
1934-35	?	973	Below Brookdale (1)
1938-39	?	412	Below Brookdale (1)
1939-40	?	1,081	Below Brookdale (1)
1940-41	?	671	Boulder Creek (2)
1941-42	Dec 24 - Apr 11	827	Boulder Creek (2)
1942-43	Dec 26 - Apr 22	624	Boulder Creek (3)
1976-77	Jan-Apr	1,614	Felton Diversion (4)
1977-78	Nov 21 - Feb 5	3,000 (Estimate)	Felton Diversion (4)
1978-79	Jan-Apr	625 (After drought)	Felton Diversion (4)
1979-80	Jan-Apr ?	496 (After drought)	Felton Diversion (4)
1982-83		1,506	Alley Estimate from 1981 Mainstem Juveniles only
1994-95	6 Jan-21 Mar (48 of 105 days-Jan-15 Apr)	311 (After drought)	Felton Diversion (5) Monterey Bay Salmon & Trout Project
1996-97		1,076	Alley Estimate from 1994 Mainstem Juveniles only
1997-98		1,784	Alley Estimate from 1995 Mainstem Juveniles only
1998-99		1,541	Alley Revised Estimate from 1996 Mainstem Juveniles only
1999-2000	17 Jan-10 Apr	532 (above Felton)	Monterey Bay Salmon & Trout Project
1999-2000		1,300	Alley Index from 1997 Mainstem Juveniles only
2000-01	12 Feb-20 Mar	538 (above Felton)	Monterey Bay Salmon & Trout Project
2000-01		2,500	Alley Index from 1998 Juveniles in Mainstem and 9 Tributaries
2001-02		2,650	Alley Index from 1999 Juveniles in Mainstem and 9 Tributaries
2002-03		1,650	Alley Index from 2000 Juveniles in Mainstem and 9 Tributaries
2003-04		1,600	Alley Index from 2001 Juveniles in Mainstem and 9 Tributaries

(1) Field Correspondence from Document # 527, 1945, Div. Fish and Game.
(2) Field Correspondence from Document #523, 1942, Div. Fish and Game.
(3) Inter-office Correspondence, 1943, Div. Fish and Game.
(4) Kelley and Dettman (1981).
(5) Dave Strieg, Big Creek Hatchery Manager, pers. comm. 1995.

DISCUSSION

Mainstem's Juvenile Numbers and Habitat Conditions

As a whole, mainstem production of YOY's had steadily declined from 1997 to 2000 with 81,300, 52,500, 34,300 and 18,200, respectively (**Table 54**). The continued decline in 2000 was likely related to reduced adult returns after the El Niño period. However, mainstem YOY production increased in 2001 back to 30,600 despite lower streamflow than in 2000. Yearling numbers continued to decline for 1997-2001 with 8,400, 5,500, 7,300, 5,600 and 4,800, respectively. The YOY decline occurred in all three segments of the mainstem. As a result of yearling densities and YOY's that grew into the larger size class, the 1997-2001 estimates for larger, smolt-sized juveniles produced in the mainstem continued to decline with 24,800, 26,600, 24,100 and 12,500 and 11,700, respectively (**Table 55**). Only the lower River produced more smolt-sized fish in 2001, this being due to more YOY's growing into Size Class 2. In 2001, there were fewer yearlings and YOY's grew more slowly with reduced streamflow than past years. Closer evaluation of the three sub-units of the mainstem (lower, middle and upper) indicated that 2001 YOY production was much improved in all three, although it remained less than 1999 production in the lower and middle River. YOY production has not yet returned to 1997 and 1998 levels. The production of larger juveniles was at a 5-year low for the middle River and remained low in the lower and upper River as had been the case in 2000. A more detailed examination and explanation will follow.

Lower River. YOY numbers were similar in the lower River in 1998 (15,700) and 1999 (15,000), but totaled only 4,900 in 2000 and 9,100 in 2001. The 2001 YOY production was about 60% of the 1998 and 1999 estimates. Yearling production in the lower River in 2001 (1,000) was similar to 2000 (1,200) and 1998 (1,100) but only about half of 1999 production (2,100). Numbers of larger juveniles in the => 75 mm SL range were similar in 1997 (14,400), 1998 (14,700) and 1999 (15,900) in the lower River, indicating that the carrying capacity for the valuable larger juveniles remained in the 14,000-16,000 range over the three years. But numbers plummeted in 2000 (4,500) and remained low in 2001 (6,400). In 2000 there were much fewer YOY's than the past, and they usually grow into the larger size in the lower River. There were fewer yearlings in both 2000 and 2001. In 2001, growth rate was reduced with a smaller proportion of YOY's reaching larger size. In 1998 with high baseflow and likely the greatest spawning success later in the winter and spring, 13,600 YOY's (87%) reached Size Class 2. In 1999-2001 there were 13,300 (89%), 3,900 (80%) and 5,100 (56%), respectively, that reached Size Class 2.

Rearing habitat quality in 2001 improved overall in the lower River fastwater habitat with regard to reduced embeddedness and more escape cover except for cover in riffles in the Gorge. However, some aspects of habitat quality declined. There was reduced streamflow, which reduced depth, whitewater cover and insect drift rate. Percent fines also increased in 2001. The fall baseflow in the lower River in 2001 was 10-30% less than in 2000 and the lowest since 1994, with the greatest decline in the upper portions (**Table 19**). Baseflow declined to 20 cfs at the Big Trees Gage by early

July in 2001, but not until early October in 2000.

Egg survival in 2001 was probably higher than in 2000 because there were no bankfull events and only one near 1800 cfs in 2001, occurring in late February (**Figure 42**). Bankfull discharge is typically considered to reoccur every 1.5 years (recurrence interval). Bankfull discharge is the minimum flow thought to have channel-forming capabilities, and may be the approximate flow when spawning beds begin to wash away or become smothered with sediment.

For the San Lorenzo River, the flood flow with a recurrence interval of 1.5 years at the Felton Big Trees Gage is 4,300 cfs, based on the flood flow frequency analysis using the Gumbell Extreme Value Method for 60 years of data from 1937 through 1996. A flood frequency analysis done on the Russian River at three locations concluded that the estimated flood frequency corresponding to bankfull discharge was different for each site; 1.3, 1.7 and 2 years (**Williams and Associates 1997**). On the San Lorenzo River the flood flow of 2,800 cfs had a 1.3 recurrence interval, may be within the range of the estimated bankfull event.

On the other hand, in 2000 there were at least 3 bankfull events occurring in January and February (**Figure 41**). In 2000, the large stormflows came later than in the three previous years, with 6 peak flows greater than 1,800 cfs occurring in middle to late February. Another late storm came in middle April 2000, which may have moved sediment, buried some redds and/or scoured others. In the 1999 water year, only one storm event produced a bankfull event capable of scouring steelhead redds at potentially a significant level (**Figure 40**). It occurred in early February. In 1998 there were at least 4 bankfull events in January and February (**Figure 39**). In 1997 there were 4 bankfull events in December and January (**Figure 38**). In 1996 there were 5 bankfull events between mid-January and mid-March (**Figure 37**). Despite the more favorable conditions with less potential for redd scour than in earlier years, YOY production in the lower River in 2001 was not fully recovered to the 1997-1999 levels.

Middle River. The middle River had shown continued annual decline in YOY production in 1997-2000 with 33,000, 31,100, 12,600 and 3,200, respectively (**Table 54**). However it rebounded somewhat in 2001 to 10,000, as it had in the lower River and most of the watershed. It was still down from pre-El Niño effects. The numbers of yearlings produced in 1997-2001 showed a continued decline with 3,600, 2,100, 1,800, 700 and 500, respectively. Numbers of smolt-sized juveniles in 1997-2001 showed a progressive decline with 7,000, 8,500, 4,300, 2,100 and 1,400, respectively (**Table 55**).

Fewer yearlings in 2001 may have resulted from the considerable reduction in YOY's in 2000 compared to earlier years. As in the lower River, the same habitat conditions improved at fastwater sampling sites, including reduced embeddedness and more escape cover. Percent fines were similar to 2000. However, water depth and insect drift declined due to reduced streamflow. Baseflow declined 20-30% at sites in the middle River in 2001 compared to 2000 (**Table 19**). Growth rate of YOY's was reduced with reduced streamflow. A positive correlation has been developed between streamflow and the percent of YOY's reaching Size Class 2 (**Alley et al. Draft Report 2002**). In 2001 there were 700 of 10,000 YOY's (7%) that reached Size Class 2. In 2000 there were 1,400 of 3,200 YOY's (44%) that reached Size Class 2. There was much less competition in 2000 with fewer fish, which promoted growth. In 1999 there were 2,400 of 12,600 YOY's (19%) that reached Size Class 2.

Upper River. The upper River above the Boulder Creek confluence in 2001 was still recovering from the high quantity of sediment entering the mainstem in 1998. Estimated Y-O-Y production in 1997 through 2001 was 25,800, 5,800, 6,800, 10,000 and 11,500, respectively (**Table 54**). The 2001 improvement came from production in Reaches 10 and 11 with a decline in Reach 12 production in Waterman Gap (**Table 52**). Adult access to Waterman Gap may still have been restricted by the illegal log dam, road riprap in the River and the Highway 9 culvert crossing and concrete apron that were observed in 2000. There also may have been much more competition from yearlings in Reach 12 because of their increased density in 2001. The estimated number of yearlings in the upper River in 1997-2001 was 3,400, 2,200, 3,400, 3,800 and 3,300, respectively. Yearlings were nearly doubled in Reach 12 compared to 2000, but numbers were down in the other reaches. Production of larger juveniles (=> 75 mm SL) in 1997-2001 was 3,400, 3,500, 3,900, 4,500 and 3,900 respectively. Surprisingly, more YOY's grew into Size Class 2 in 2001 than 2000 despite the reduced streamflow. In 2001 there were 1,200 YOY's (10%) that reached Size Class 2. In 2000, 400 (4%) reached Size Class 2. Fall baseflow had declined at least 50% in 2001 in the upper River (**Table 19**). The higher growth rate was observed in Reaches 10 and 11, with slower growth rate in Reach 12, where yearling density had increased to a 5-year high. This unusual result may have resulted from earlier spawning success in 2001, leading to a longer growth period before fall sampling. Also, yearling density was much reduced in Reaches 10 and 11, offering less competition for YOY's and possibly allowing them to grow faster.

Habitat in the upper River continued to improve slightly in 2001 as it had in 2000. As in the lower and middle River, embeddedness was similar or slightly less in 2001. Escape cover was improved in pools and run/step-run habitat. Percent fines were reduced in pools in Reach 11 and run/step-runs in Reaches 10 and 12. Percent fines were similar in riffles in the upper River and increased in pools of Reach 12. Habitat depth declined at all sites except at Site 12a in the canyon below Waterman Gap where scour apparently had occurred.

Juvenile Numbers and Habitat Conditions in Tributaries- Discussion

Branciforte Creek. In 1998-2001, Branciforte Creek YOY steelhead production was 14,800, 9,500, 11,300 and 11,700, respectively (**Table 54**). Yearling production in 1998-2001 was 1,900, 3,100, 2,800 and 2000, respectively. Production of larger juveniles (=> 75 mm SL) in 1998-2001 was 3,300, 3,100 and 2,800, and 2000, respectively (**Table 55**). Therefore, YOY production was similar and yearling and larger juveniles were down considerably (29%) compared to 2000.

Habitat quality at sampling sites did not change in any consistent manner in 2001 with regard to non-streamflow related factors. Mean pool depth increased at both sites, but maximum depth decreased slightly. In the lower site, fastwater habitat decreased in embeddedness while pools increased. The opposite was true for embeddedness at the upper site. Escape cover increased in pools at the upper site and declined at the lower site. Escape cover was probably the most important habitat parameter, indicating improved habitat in the upper site and habitat loss at the lower site. However, only YOY density improved at the lower site. Percent fines decreased at the lower site in pools and runs. Streamflow likely declined in 2001, as was measured in other tributaries, although no measurements were taken in Branciforte Creek. The reduction in yearling density at both sites indicated reduced rearing habitat quality.

Carbonera Creek. In 1998-2001, the YOY steelhead production in Carbonera Creek was 6,900, 4,900, 3,500 and 4,100, respectively. Production of yearlings in 1998-2001 was 600, 1,500, 2,000 and 1,200, respectively. Production of valuable, larger juveniles (=> 75 mm SL) in 1998-2001 was 2,500, 1,600, 2,000 and 1,200, respectively. Thus, the pattern of production change was the same as Branciforte Creek; increased YOY's, reduced yearlings and reduced Size Class 2 fish.

Habitat conditions generally worsened in Carbonera Creek in 2001. The positive change was more escape cover and reduced percent fines in pools of the upper site. Habitat depth declined at both sites and escape cover in pools of the lower site worsened. Percent fines increased in runs/step-runs of both sites but lessened in lower site riffles slightly. Streamflow likely declined in 2001, as was measured in other tributaries, although no measurements were taken. The reduction in yearling density at both sites indicated reduced rearing habitat quality.

Zayante Creek. Total juvenile steelhead densities rebounded in Zayante Creek in 2001 after falling substantially in 2000. The increased came from increased YOY's, despite reduced yearlings in all but the uppermost reach. YOY production in 1998-2001 was 19,800, 22,000, 9,300 and 15,100, respectively. Production of yearlings in 1998-2001 was 1,700, 6,700, 3,700 and 3,500, respectively. Production of valuable, larger, smolt-sized juveniles (=> 75 mm SL) in 1998-2001 was 3,800, 7,500, 5,000 and 3,500, respectively. Therefore, although yearling production was similar between years, growth rate was reduced in 2001 to produce fewer Size Class 2 fish.

In Zayante Creek, a general improvement in habitat quality was observed related to escape cover. It increased in pools at all 4 sites. Fallen trees existed at the second and third sites (13b-c). Mean and maximum pool depth increased at the lower and third site upstream, despite the reduced streamflow. Pool depth declined significantly at only Site 13b. Degraded factors included similar or higher embeddedness fastwater and pool habitat. Percent fines were similar or increased in fastwater habitat at all sites. However, percent fines increased in pool habitat at all sites. Fall baseflow was reduced 10% at Site13a and by 1/3 at Site 13b above Bean Creek confluence (**Table 19**). These reduced streamflows were responsible for reduced growth rate in YOY's in 2001. In 2000 there were 1,400 YOY's that grew into Size Class 2, whereas only about 100 YOY's did so in 2001 (**Tables 54 and 55**).

Bean Creek. In 1998-2001, YOY steelhead production was 17,900, 6,100, 15,000 and 8,300, respectively. Yearling production was 1,500, 4,200, 2,300 and 3,000, respectively. The production of larger juveniles (=> 75 mm SL) was 1,600, 4,200, 2,400, and 2,900, respectively. However, production estimates in 2001 may have been inflated because an additional unknown extent of Bean Creek went dry in Reach 3 in 2001. The sampling site in 2001 in Reach 3 had to be moved upstream to the 1999 site location because the 2000 site was dry. The yearling density at Site 14c was much higher in 2001, and the YOY density was much lower compared to Site 14c in 2000.

Habitat quality in Bean Creek generally improved at sites in 2001. Escape cover and depth were increased in pools at all three sites, despite the reduced streamflow. Embeddedness in pools declined at the lower and upper sites as did embeddedness in fastwater habitat at the upper site. Improved embeddedness at the upper site was probably due its location being further upstream. Percent fines increased in riffle and run habitat of the lower and upper sites and was similar in other habitats. Measured streamflow at Site 14b was slightly higher in 2001 than 2000.

Reach density of YOY's declined substantially in the upper reach in 2000, though it increased in the lower and middle reaches. Yearling density was much reduced at the lower site and much increased at the upper site (unusual for 2001 and may be primarily due the change in site location). The habitat improvement was consistent with the increased Size Class 2 fish production in 2001.

Fall Creek. In 1998-2001, YOY steelhead production in Fall Creek was 5,800, 5,800, 3,500 and 3,900, respectively. Yearling production was 500, 1,400, 700 and 1,000, respectively. Production the larger juvenile size classes was 1,000, 1,400, 700 and 1,000, respectively. Thus, YOY's and yearlings increased in 2001.

The juvenile population increased with improvement of some aspects of habitat quality in 2001. Improvements included more pool escape cover in the form of woody debris, greater depth in run/step-run habitat and reduced fastwater habitat embeddedness. Most habitat was fastwater in Fall Creek. Pool depth declined and pool embeddedness increased, although percent fines in pools declined. Despite less embeddedness, percent sand increased in fastwater habitat. Fall baseflow was the same in both 2000 and 2001 (**Table 19**).

Newell Creek. In 1998-2001, YOY production was 3,600, 1,000, 1,100 and 2,000, respectively. Yearling production was 400, 1,300, 500 and 300, respectively. Production of large juveniles (=> 75 mm SL) was 400, 1,300, 500 and 300, respectively. YOY production increased as was typical of tributaries in 2001, while yearling production remained lower and similar to the 2000 level.

Habitat conditions that improved in Newell Creek in 2001 included reduced percent fines in riffles, runs and pools, more escape cover in pools due to more overhanging vegetation and reduced embeddedness in fastwater habitat. Conditions that worsened were reduced pool depth and more pool embeddedness. The continued low yearling numbers despite habitat improvement was unclear. The reduced pool depth implied that streamflow was less in 2001, though it was not measured. It had been measured at 0.5 cfs in 2000 (**Table 19**).

Boulder Creek. In 1998-2001, YOY production in Boulder Creek was 13,400, 5,800, 5,300 and 7,900, respectively. Yearling production was 1,300, 3,100, 1,800 and 1,900, respectively. Production of larger juveniles (=>75 mm SL) was 2,200, 3,100 and 1,800 and 1,900, respectively. Thus, YOY production increased as it had in most tributaries, while yearling numbers were similar to 2000. In such a confined canyon the threat of high winter stormflows flushing out yearlings and causing scour of spawning redds was likely not as great a problem in 2001 as in previous years. There may have been more spawners in 2001 as well as more successful spawning success. YOY densities increased at all three sampling site, especially at the lower Site 17a (**Table 61**). Yearling density much improved at the middle Site 17b, declined greatly at the lower site and was similar at the upper site in 2001.

Habitat quality mostly improved in the upper site and mostly declined at the lower two sites in 2001, although pool escape cover improved at all 3 sites. In the uppermost Site 17c, the following parameters improved; more pool escape cover, greater pool depth, less sand in fastwater habitat (similar in pools) and reduced embeddedness in fastwater habitat and pools. The sediment apparently moved down into the middle reach where pool and fastwater habitat depth decreased and sand and embeddedness increased in fastwater habitat. However, pool substrate at Site 17b improved with lower embeddedness, more escape cover and much higher densities of yearlings. The lower site had more escape cover in pools and less sand in riffles. However, maximum depth declined, depth in run/step-run habitat declined, percent sand and embeddedness increased in step-run habitat and embeddedness increased in pool habitat while percent sand was similar. The cause of substantial decline in yearlings at the lower site was unclear.

Bear Creek. In 1998-2001, YOY production in Bear Creek was 18,100, 16,700, 8,300 and 13,000, respectively. The yearling production was 1,200, 5,500, 3,000 and 2,900, respectively. Production of larger juveniles (=> 75 mm SL) was 2,250, 5,500, 3,700 and 2,600, respectively. Therefore, YOY production rebounded as it had in most other tributaries and yearling numbers remained similar to 2000 levels as had occurred in Boulder Creek. Growth rate of YOY's and yearlings was reduced in 2001, with some yearlings actually being in Size Class 1 and Size Class 2 fish declining in number. Streamflow declined nearly 50% at lower Site 18a in 2001 to perhaps slow growth rate.

Habitat conditions mostly deteriorated in Bear Creek in 2001 after improvement the two previous years. Water depth declined in all habitats at both sites except in step-run habitat at the upper site. Percent fines and embeddedness increased in all habitats except pools at the lower site, and embeddedness greatly improved in step-runs at the upper site. Pool escape cover increased slightly at the lower site, but only YOY densities dramatically increased while yearling density decreased. Yearling densities improved at the upper site where escape cover decreased in pools in 2001.

Kings Creek. In 1998-2001, YOY production in Kings Creek was 3,300, 2,700, 3,800 and 3,400, respectively. Yearling production was 300, 1,200, 600 and 1,300, respectively. Production of larger juveniles (=> 75 mm SL) was 1,700, 1,200, 600 and 1,100, respectively. Therefore, unlike in most tributaries, YOY production was down while yearling production was up in Kings Creek in 2001. Streamflow was reduced to a trickle in 2001.

There was the first indication of habitat improvement in upper Kings Creek since the El Niño winter of

1997-98 that brought considerable sedimentation. There was more escape cover there with higher mean pool depth, despite the reduced streamflow in 2001. There was also less sand in riffles at both sites. However, other factors continued to worsen or were unchanged, such as reduced mean pool depth at the lower site and reduced maximum pool depth at both sites. Percent fines were similar or increased in all habitat types except riffles. Embeddedness increased in pools and step-runs at the upper site.

Mainstem and Tributary Contributions to the Adult Steelhead Index

The index of adult returns expected from mainstem juveniles declined throughout the period, 1995-2000, with a slight increase in 2001 (**Figure 22**). The mainstem increase resulted from the higher number of YOY's that grew into Size Class 2 in 2001 and occurred despite the fewer yearlings present. A smaller proportion of YOY's reached smolt size in 2001 than 2000, but there were many more YOY's in 2001 in the lower River, where YOY growth rate allowed some to grow to smolt size the first year. Despite the rebound in YOY's in the tributaries, the fewer larger juveniles resulted in a lower tributary index of adults in 2001, the lowest in the 4 years of measurement. **Tables 62 and 63 and Figure 22a-b** summarize the indices of adult spawners expected from the mainstem juveniles produced in 1981 and 1994-2001, as well as indices of adult spawners from tributary juveniles produced in 1998-2001. **Indices from mainstem juveniles for 1998-2001 were 1,280, 1,150, 560 and 610 adults, respectively, representing a 9% increase from 2000 to 2001.**

The proportion of adults expected to contribute to the adult run from mainstem juvenile production in 1998-2001 was 52%, 43%, 35% and 38%, respectively, indicating a slight increase in mainstem contribution mainly due to increased YOY production there. Dividing the contribution to the mainstem adult index into lower, middle and upper River, juvenile production from the **lower River** in 1998-2001 represented 50%, 62%, 41% and 50% of the mainstem adult index and 26%, 27%, 14% and 19% of the total watershed adult index, respectively. Juvenile production from the **middle River** in 1998-2001 represented 36%, 20%, 18% and 16% of the mainstem adult index and 19%, 9%, 6% and 6% of the watershed adult index, respectively. Juvenile production from the **upper River** in 1998-2001 would represent 14%, 18%, 41% and 34% of the mainstem adult index and 7%, 8%, 14% and 13% of the total watershed adult index, respectively.

Adult indices from tributary juveniles from 1998-2001 were 1,180, 1,520, 1,070 and 980, respectively, representing a 9% decline (Figure 22a). The decline came mostly from the Branciforte sub-watershed where yearling production was down without a substantial increase in YOY production. In looking at the relative contributions of each tributary to the adult index, Zayante-Bean continued to be the most important sub-watershed, followed by the Branciforte-Carbonera sub-watershed, Bear and Boulder creeks. The percent of the adult index expected from juveniles produced in the various tributaries in 1998-2001 were as follows; Zayante sub-basin contributing 15%, 23%, 25% and 23.5%, Branciforte sub-basin contributing 13%, 10%, 16% and 12.5%, Bear Creek contributing 6.5%, 11%, 12% and 10%, Boulder Creek contributing 6%, 6%, 6% and 7%, Fall, Newell and Kings, combined, contributing 8%, 8%, 7% and 8% (Table 61; Figure 22b). **Adult indices from**

mainstem and tributary juveniles combined for 1998-2001 were 2,470, 2,670, 1,640 and 1,580 adults, respectively, representing a slight decline from 2000 to 2001.

Assumptions Associated with Determining the Adult Index

The estimated number of returning adults from the Dettman model was probably high before the 50% reduction was factored in. We have no data to indicate the actual survival rates of smolts to adulthood or the percent of repeat spawners. But for comparison purposes, the model provided insight, assuming the return rate has not changed significantly from 1981 to 1999. This assumption appeared reasonable until 1999, based on return rates over the years at the Mad River hatchery for marked adult steelhead returns (**Table 65**). Data from 20 years of marking hatchery- planted yearlings in the Mad River and enumerating returning marked adults indicated no overall trend in return rate, though there were annual fluctuations. In addition, prior to 1998 our index of adult returns was based on mainstem juveniles only, and was just a partial estimate because it excluded a sizable number of juveniles in the tributaries and did not incorporate the hatchery augmentation of smolt-size juveniles. Based on trapping data from the 1930's, 1940's and 1970's, the model's index of adult returns for the late 1990's appear to be within the expected range of year-to-year variation in returning adults.

The return rates in the early 1970's were about the same as in the late 1980's. However, the sharp decline in YOY numbers in portions of the mainstem and in most tributaries in 1999 and 2000 without substantial habitat deterioration may indicate an atypical drop in adult returns for those years. In 2001 the YOY production rebounded to pre-El Niño levels.

Smith detected much reduced steelhead YOY densities in Scott and Waddell creeks in 1999 (Smith 1999). However, In Scott Creek they were similar to 1997 levels when streamflow was similar. He also attributed low densities to suppression by coho salmon competition. Coho competition was used to explain the decline in Waddell Creek, where he noted that combined densities of steelhead and coho juveniles were similar between 1998 and 1999 at some sampling sites.

Projection of Future Status of Coho Salmon and Steelhead Populations and Habitats

The future of salmonid populations in the San Lorenzo River will depend the status of limiting factors. Limiting factors include sediment, adult passage impediments, streamflow and water temperature. Sediment impacts both spawning success and rearing. Passage impediments affect spawning access and spawning success. This species spawns in the early winter when stormflows are often lacking. Then its spawning nests are vulnerable to sedimentation and scour from later winter storms. Streamflow in winter affects passability of potential impediments to spawning migration and rearing success (growth and survival). Water temperature affects metabolic rate and food requirements, which determine growth rate and survival.

Coho salmon are more vulnerable than steelhead to sediment impacts and have more difficulty in negotiating passage problems because they spawn earlier in the winter. Coho salmon are more vulnerable to streamflow effects on rearing and food availability because they cannot inhabit fastwater areas with more food that steelhead exploit. Coho are more negatively impacted by warmer water temperature than steelhead because they inhabit slower water areas where food is less available. We suspect that the last two drought periods, 1976-77 and 1987-1992, were devastating to coho salmon and virtually eliminated them from the San Lorenzo River.

The San Lorenzo River is at the southern edge of the coho salmon ESU for which coho are federally listed as a Threatened species. Coho salmon are state listed as an Endangered Species south of San Francisco Bay. Coho salmon are doing poorly in all streams south of San Francisco Bay, with two of three age classes weak and precarious. If the remaining strong year class is impacted by drought or heavy winter stormflows that result in poor spawning success, species extinction in this region is possible without human intervention through hatchery propagation and a captive breeding program. Juvenile coho have not been detected in the San Lorenzo system since 1981. A few adults were trapped at Felton in the early 1990's, but none in recent years. It appears that coho have been extirpated from the system. Restoration of this species will require hatchery re-introduction, protection from angling and improved water management during drier winters so as to insure adequate adult passage flows to spawning areas. The San Lorenzo River Gorge is a formidable passage problem for the coho in years when winter rains are delayed or few in number. Water diversion during a drought year, in combination with naturally low baseflow, may prevent adult salmonid access to the upper watershed above the Gorge or at least severely limit it. Mean daily streamflow was less than 50 cfs at the Big Trees Gage for most of the winter from winter of 1986-87 through winter of 1990-91 (5 years), except for one to three minor storm events each winter (Alley et al. 2002). Other restoration efforts must include better road maintenance and enforcement to deal with chronic sediment input that leads to pool filling and protection of large, streamside trees that will eventually serve as sources of large woody material and habitat complexity if retained in-channel without being cut up by County maintenance crews or landowners.

Monitoring of the juvenile steelhead population began in 1994 after a 5-6 year drought. **Figures 21a-f** summarize available juvenile production estimates. Mainstem estimates by size class were made for 1981 and 1994-2001. Age class distinctions began in 1996 for population estimates. Sampling of tributaries and habitat typing was expanded in 1998 to allow production estimates in tributaries from 1998-2001. Baseflow was relatively lower in 1981, 1994, 1997 and 2001 for the years of monitoring. Baseflow was relatively high in 1995-96 and 1998-1999, with the El Niño high stormflows occurring the winter prior to the 1998 sampling. Data show that annual YOY production in the mainstem and tributaries may vary considerably, while yearling production is less variable and affected by large storm events that prevent successful overwintering and reduced recruitment from a small YOY population the previous year (**Figures 21a and 21b**). Mainstem production of smolt-sized juveniles (=>75 mm SL) is much influenced by baseflow, with drier years generally having fewer and wetter years having more (**Figure 21d**). In tributaries we see the lowest smolt-sized juvenile (and yearling) production in four years in 2001 with the lowest baseflow and the smallest YOY recruitment from the previous year (**Figures 21b and 21e**). Although YOY production made an up-swing in the watershed in 2001, smolt production remained low, presumably a continued affect of El Niño events 4 years previous (**Figure 21f**).

It has been shown that growth rate of YOY juveniles in the mainstem is positively correlated with streamflow, and the number of YOY's that reach smolt size in the Middle River is highly correlated with mean monthly baseflow for May-September (**Alley et al. 2002**). Survival of juveniles in the ocean is size-dependent, meaning that larger smolts have a higher probability of returning as adults. Therefore, slow growth rates resulting from reduced streamflow negatively impacts adult numbers. Past observations in the San Lorenzo River Gorge indicate that adult steelhead passage becomes difficult at streamflows below approximately 70-100 cfs. This is due to critically wide riffles and boulder falls that develop, such as locations in the upper Rincon and Four Rock area. Monitoring has indicated that the high storm events associated with El Niño degraded habitat in tributaries and the mainstem due to sedimentation resulting from erosion. These high stormflows also flushed many yearlings out of the system. YOY production was good that spring after the storms and growth rates were high. However, low YOY production occurred two years later that resulted from adults returning mostly from those smolts surviving the El Nino events and poor oceanic conditions.

Instream flow may be expected to diminish in the future, thus increasing the limiting affects of reduced streamflow on steelhead population size and restoration of coho salmon. Unless additional or alternative water supplies are exploited along with greater use of treated effluent and per capita reduction in water use, human water demand may be expected to increase with associated loss of streamflow and increased difficulty for adult salmonids to negotiate passage impediments. The impacts will be most severe during drought.

Modification of passage impediments may lessen the impact of reduced streamflow during drought. Re-designing of surface water diversion systems to promote maximum instream flow with diversion points placed as far downstream as possible will benefit fish. If water stored in Loch Lomond were released down Bear or Lompico creeks and withdrawn downstream as far as possible for municipal use, the fish would benefit. The very best watershed management to reduce erosion and sedimentation of stream channels should take place in the Newell Creek watershed, upstream of Loch Lomond. The pool volume in the reservoir must be preserved to minimize the need for water diversion from the San Lorenzo River. Use of wells further from streams instead of surface water diversion during dry years may alleviate some of the loss in surface flow and reduce fishery impacts. The extent of the water shortage and duration of the next drought will serve to determine the lag time after which the steelhead population may recover. Impacts similar to the last drought will prevent restoration of a self-sustaining coho population. The human population size has increased in Scotts Valley and Santa Cruz, as well as in the San Lorenzo Valley since the last drought that ended approximately 10 years ago. Over-drafting of the Santa Margarita aquifer is a concern of many. Therefore, the next drought may have more severe effects on the steelhead population than previous ones. Two or more successive drought years will have the greatest severity. Until increased water sources are developed that do not reduce instream flow, there may need to be a building moratorium on development that would rely on additional water from the San Lorenzo River watershed.

The middle River has been substantially impacted by sedimentation and fluctuations in baseflow, causing fluctuations in the growth rate of YOY juveniles and production of larger juveniles. The middle

River is warm, as is the lower River, requiring juveniles to seek out fastwater habitat that greatly increases with higher summer baseflow. The middle River potentially produces many smolt-sized juveniles in wetter years. The great value of the mainstem River is its production of larger, smolt-sized juveniles. However, since 1998, the contribution of the mainstem River to smolt production has diminished from 26,000 (1998) to 24,000 (1999) to 11,000 (2000) to 11,500 (2001). This decline primarily resulted from fewer YOY's utilizing the mainstem with 52,500 in 1998 to 34,500 (1999) to 18,000 (2000) and then slow growth of the 30,500 estimated in 2001.

Erosion, sedimentation and habitat degradation may be expected to increase in the future in association with increased road building in suburban areas, increased impermeable surfaces, higher stormflow from increased runoff and less percolation, continued logging without adequate protection of the riparian corridor and lack of maintenance of erosion control measures during re-entry periods, increased clearing of forested areas for human development and increased use of unpaved road surfaces, continued clearing of streamside vegetation by streamside residents and continued removal or cutting of instream large woody material. Watershed management that may off-set these negative impacts include increased paving of rural unpaved roads, better education of streamside residents regarding retention of riparian vegetation and in-channel large woody material, greater enforcement of the riparian corridor ordinance, establishment of no cut buffers along stream courses in logging areas, maintenance of erosion control measures in logged areas, increased efforts at erosion control along streambanks with proper revegetation and placement of large woody material at erosion control sites. Housing developments should be designed to minimize paved surfaces, maximize open space and provide percolation basins to capture increased runoff before it can reach stream channels. Strategically placed sediment catchment basins may be constructed on non-fish bearing streams to capture sediment before it can enter fish habitat during large flood events. However, these basins must be excavated periodically as they fill up.

Without better watershed protection, repair and planning, impacts of El Niño-like stormflows and drought to steelhead will become more severe, and the habitat recovery time will increase. The likelihood of permanent extirpation of coho salmon and a permanently reduced steelhead population will also increase.

Data Gaps

Annual monitoring of steelhead needs to continue through the next drought period and beyond to assess the extent of population recovery. More fish and habitat monitoring needs to occur in the lower mainstem in the flood control channel and lagoon/estuary to assess success of management efforts. More fish sampling needs to occur in upper Zayante Creek and Mt. Charlie Gulch adjacent to Santa Cruz City watershed lands to assess success of management efforts. There is a shortage of streamflow data on the San Lorenzo River mainstem and tributaries. More stream gages should be established and maintained in the watershed to better correlate streamflow with habitat conditions and fish densities and to detect insufficient streamflow. Mainstem locations for gages would include Waterman Gap, above and below the Boulder Creek confluence on the mainstem. Tributaries that need better gaging include

Zayante Creek (above and below the Bean Creek confluence), Bean Creek (below the Lockhart Gulch confluence) and Boulder Creek (near the mouth).

Table 65. Rates of Return from Mad River-Planted Steelhead Yearlings to Adults at the Mad River Hatchery, 1972-92. (Winter steelhead marked 1972-77; summer steelhead marked 1981-91).

Year of Planting	Number of Marked Yearlings Planted	Total Number of Marked Returning Adults	Return Rate
1972	20,125 (unknown # marked)	46	0.00229 ?
1973	60,555	250	0.00413
1974	20,400	1	0.00005
1975	43,475	324	0.00745
1976	80,935 (unknown # marked)	172	0.00212 ?
1977	27,946	1091	0.0390
1978	51,660 (none marked)		
1979	57,280 (none marked)		
1980	60,180 (none marked)		
1981	94,355 (summer STH)	56	0.00059
1982	73,000 (summer STH - none marked)		
1983	58,075 (summer STH)	557	0.00959
1984	No marked fish released		
1985	No marked fish released		
1986-90*	456,729	981	0.00215**
1990	70,011	193	0.00276**

*** Fin Clips were the same for this group of yearlings.**

**** May be a low estimate because data stopped in 1992, and more adults may have returned in 1992-1993 from those planted in 1990.**

(This table is Alley's compilation of data from CDFG Annual Administrative Reports from the Mad River Salmon and Steelhead Hatchery, 1973-91. Region 1, Inland Fisheries.)

CONCLUSIONS

Differences in densities of juvenile size classes and age classes between 2000 and 2001 were statistically analyzed. Both Size Class 1 and Age Class 1 increased in density over the whole basin (**Table 43a**) by more than 8 fish per 100 feet. This difference was highly significant statistically. Both Size Class 2 and Age Class 2 decreased by slightly over 1 fish per 100 feet. But the difference was not statistically significant due to variation and the small difference seen. The results were essentially the same both in significance and magnitude for the two subdivisions of the basin (**Tables 43b and 43b**), yielding significant increases in Size Class 1 and Age Class 1 for the mainstem sites and separately for the upper mainstem with tributary sites.

As a whole, mainstem production of YOY's increased in 2001 after a 4-year decline. The annual mainstem estimates were 81,300, 52,500, 34,300, 18,000 and 30,600, respectively, for 1997-2001 (**Table 53**). Mainstem yearling numbers continued to decline for 1997-2001 with 8,400, 5,500, 7,300, 5,600 and 4,800, respectively. As a result of number of yearlings and relative low growth rates of YOY's in 2001 compared to the three previous years with higher streamflow, the 1997-2001 estimates for larger, smolt-sized juveniles produced in the mainstem were 24,800, 26,600, 24,100, 11,100 and 11,700, respectively (**Table 54**). Thus, production of smolt-sized juveniles in the mainstem continued to remain relatively low compared to previous years. The 2001 increase in mainstem YOY's came from better production in the lower and middle River. The 2001 decrease in mainstem yearlings occurred throughout.

We suspect that the increased mainstem YOY production in 2001 partially resulted from higher spawning success in winter 2000-2001 than the two previous years due to milder stormflows with less substrate-moving storm events that could either scour or bury nests in sediment (**Figure 42**). There were likely more adults returning during winter of 2000-2001 than the winter before, which was supplied with adults from juveniles being negatively impacted by El Niño storms and poor oceanic conditions (**Alley 2001**). The trapping data at the Felton Diversion Dam indicated more adults returning in 2001. In addition, smolt planting in spring of 1999 by the Monterey Bay Salmon and Trout Project had resumed to pre-El Niño levels in 1999, contributing adults to the 2000-2001 winter run. The smolt planting numbers for spring, 1995-2001, were 42,300, 28,800, 32,000, 2,200, **30,600**, 20, 400 and 22,600 respectively.

Some habitat conditions were improved in the mainstem in 2001, such as increased escape cover from more overhanging riparian trees and less substrate embeddedness. However, baseflow was reduced, which resulted in less fastwater habitat, reduced insect drift rate and slower growth rate of YOY's into the larger Size Class 2. Fastwater habitat heavily used by juveniles in the lower and middle River was shallower and percent fines increased (except in Reach 5 below the Zayante Creek confluence) to reduce its quality for insect production and fish habitat. Whitewater cover was reduced in the Gorge. The uppermost Reach 12 in Waterman Gap broke with the trend by producing more yearlings and less YOY's in 2001 compared to 2000 (**Table 47**). However, this relatively high quality habitat did not suffer the reduction in YOY densities in 2000 that other sites had (**Table 46**).

Increase in YOY numbers in 7 of 9 tributaries and reduced yearlings in 5 of 9 tributaries can be attributed partially to likely increased spawners in 2000-2001 than in 1999-2000, with associated fewer YOY's from 2000 being recruited as yearlings in 2001. There was also likely higher spawning success and YOY survival with the milder winter. The exceptions where yearling densities increased in 2001 (Bean, Fall, Boulder and Kings creeks) resulted from habitat improvement regarding more escape cover and/or increased depth in pools. In general, habitat conditions related to substrate and habitat depth deteriorated in tributaries with reduced streamflow in most (except Fall and middle Bean). Embeddedness and percent fines generally increased in tributaries. However, pool escape cover generally increased due to overhanging vegetation and fallen trees resulting from the winter snowstorm. Even though most habitat indicators declined in Fall Creek except escape cover in fastwater habitat and streamflow, YOY's and yearlings increased somewhat. Bean Creek showed the greatest habitat improvement with consistent increased escape cover and depth in pools, resulting in higher yearling production than 2000. Upper Kings Creek showed the first habitat improvements (more escape cover in pools and deeper pools) since the El Nino stormflows of 1998, and yearling densities were improved. Some of the smallest YOY's and yearlings in recent years were captured in 2001 tributaries, particularly in the uppermost sites of each. This was consistent with the reduced growth rate of YOY's in the lower and middle mainstem River. The three tributaries that showed significant overall increased juvenile production (all sizes combined) in 2001 were Zayante, Boulder and Bear creeks mainly due to more YOY's. Six of 9 tributaries showed at least a slight increase.

The index of adult returns expected from mainstem juveniles declined throughout the period, 1995-2000, with a slight increase in 2001 (**Figure 22**). This increase resulted from the higher number of YOY's that grew into Size Class 2 in 2001, leading to more smolt-sized juveniles in the lower River despite fewer yearlings present. A smaller proportion of YOY's reached smolt size in 2001 than 2000, but there were many more YOY's in 2001 in the lower River, where YOY growth rate allowed some to grow to smolt size the first year. **Tables 61 and 62 and Figure 22** summarize the indices of adult spawners expected from the mainstem juveniles produced in 1981 and 1994-2001, as well as indices of adult spawners from tributary juveniles produced in 1998-2001. **Indices from mainstem juveniles for 1998-2001 were 1,300, 1,150, 560 and 610 adults, respectively, representing a 9% increase from 2000 to 2001.**

Despite the rebound in YOY's in the tributaries, the fewer larger juveniles resulted in a lower tributary index of adults in 2001, the lowest in the 4 years of measurement. **Adult indices from tributary juveniles from 1998-2001 were 1,200, 1,500, 1,070 and 980, respectively, representing a 9% decline in 2001.** The decline came mostly from the Branciforte sub-watershed where yearling production was down without a substantial increase in YOY production. In looking at the relative contributions of each tributary to the adult index, Zayante-Bean continued to be the most important sub-watershed, followed by the Branciforte-Carbonera sub-watershed, Bear and Boulder creeks. **Adult indices from mainstem and tributary juveniles for 1998-2001 were 2,500, 2,650, 1,650 and 1600 adults (rounded to the nearest 50), respectively, representing a slight decline from**

2000 to 2001.

The estimate of adult returns in 2000 had been 900 steelhead for the watershed, based on trapping data at the Felton Diversion Dam of 532 adults trapped in 85 days. No adult index from the model was available from 1997 juveniles from which to compare to the adult estimate based on trapping data. This is because only mainstem juveniles were censused and not tributaries. However, the adult index from just mainstem juveniles was 1,300. It should be noted that the model used to develop the index does not account for increased juvenile mortality rate caused by El Niño storm events, which would have created an overestimate of adult returns. The estimate from the trapping data may be considerably low because adults were able to jump over the dam during larger stormflows, thus avoiding the fish ladder and trap in 2000.

In 2001 the estimated adult return was 2,050 based on 538 adults trapped in 38 days at Felton. This estimate was less than the index of adult returns of 2,450 for 2001 (based on 1998 juvenile production). However, the two estimates are not markedly different, considering that spawning adults are often seen in the River in May after the primary spawning period that the estimate based on trapping is intended to represent. Also, adults are missed at the trap during higher stormflows because they jump over the deflated dam. It is important to note that the modeling index does not account for the contribution of hatchery smolts to adult returns, either.

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Table 1a. Defined Reaches on the Mainstem San Lorenzo River. (Refer to Appendix A for map designations.)

Reach #	Reach Boundaries	Reach Length (ft)
0	Water Street to Tait Street Diversion CM0.92 – CM1.92	5,277
1	Highway 1 to Buckeye Trail Crossing CM1.92 - CM4.73	14,837
2	Buckeye Trail Crossing to the Upper End of the Wide Channel Representation on the Felton USGS Quad Map CM4.73 - CM6.42	8,923
3	From Beginning of Narrow Channel Representation in the Gorge to the Beginning of the Gorge (below the Eagle Creek Confluence) CM6.42 - CM7.50	5,702
4	From the Beginning of the Gorge to Felton Diversion Dam CM7.50 - CM9.12	8,554
5	Felton Diversion Dam to Zayante Creek Confluence CM9.12 - CM9.50	2,026
6	Zayante Creek Confluence to Newell Creek Confluence CM9.50 - CM12.88	17,846
7	Newell Creek Confluence to Bend North of Ben Lomond CM12.88 - CM14.54	8,765
8	Bend North of Ben Lomond to Clear Creek Confluence in Brookdale CM14.54 - CM16.27	9,138
9	Clear Creek Confluence to Boulder Creek Confluence CM16.27 - CM18.38	11,137
10	Boulder Creek Confluence to Kings Creek Confluence CM18.38 - CM20.88	13,200
11	Kings Creek Confluence to San Lorenzo Park Bridge Crossing CM20.88 - CM24.23	17,688
12	San Lorenzo Park Bridge to Gradient Change, North of Waterman Gap CM24.23 - CM26.73	13,200
	TOTAL	136,293 (25.8 miles)

Table 1b. Defined Reaches For Sampled Tributaries of the San Lorenzo River. (Appendix A provides map designations.)

Creek-Reach #	Reach Boundaries (Downstream to Upstream)	Reach Length (ft)
Zayante 13a	San Lorenzo River Confluence to Bean Creek Confluence CM0.0-CM0.61	3,221
13b	Bean Creek Confluence to Tributary Transporting Sediment from Santa Cruz Aggregate CM0.61-CM2.44	9,662
13c	Santa Cruz Aggregate Tributary to Lompico Creek Confluence CM2.44-CM3.09	3,432
13d	Lompico Creek Confluence to Mt. Charlie Creek Confluence CM3.09-CM5.72	13,886
Bean 14a	Zayante Creek Confluence to Mt. Hermon Road Overpass CM0.0-CM1.27	6,706
14b	Mt. Hermon Road Overpass to Ruins Creek Confluence CM1.27-CM2.15	4,646
14c	Ruins Creek Confluence to Gradient Change Above the Second Glenwood Road Crossing CM2.15-CM5.45 (with 0.33 miles dewatered)	17,424
Fall 15	San Lorenzo River Confluence to Boulder Falls CM0.0-CM1.58	8,342
Newell 16	San Lorenzo River Confluence to Bedrock Falls CM0.0-CM1.04	5,491
Boulder 17a	San Lorenzo River Confluence to Foreman Creek Confluence CM0.0-CM0.85	4,488
17b	Foreman Creek Confluence to Narrowing of Gorge Adjacent Forest Springs CM0.85-CM2.0	6,072
17c	Narrow Gorge to Bedrock Chute At Kings Highway Junction with Big Basin Way CM2.0-CM3.46	7,709
Bear 18a	San Lorenzo River Confluence to Unnamed Tributary at Narrowing of the Canyon Above Bear Creek Country Club CM0.0-CM2.42	12,778
18b	Narrowing of the Canyon to the Deer Creek Confluence CM2.42-CM4.69	11,986
Kings 19a	San Lorenzo River Confluence to Unnamed Tributary at Fragmented Dam Abutment CM0.0-CM2.04	10,771
19b	Fragmented Dam to Bedrock-Boulder Cascade CM2.04-CM3.73	8,923

Table 1b. Defined Reaches For Sampled Tributaries of the San Lorenzo River. (Appendix A provides map designations.)

Carbonera 20a	Branciforte Creek Confluence to Old Road Crossing and Gradient Increase CM0.0-CM1.38	7,293
20b	Old Road Crossing to Moose Lodge Falls CM1.38-CM3.39	10,635
Branciforte 21a	Carbonera Creek Confluence to Granite Creek Confluence CM1.12-CM3.04	10,138
21b	Granite Creek Confluence to Tie Gulch Confluence CM3.04-CM5.73	14,203

	TOTAL	177,806 (33.7 miles)

Table 1c. Sampling Sites Used to Estimate Densities of Steelhead by Reach on the Mainstem San Lorenzo River and Tributaries, 2001.

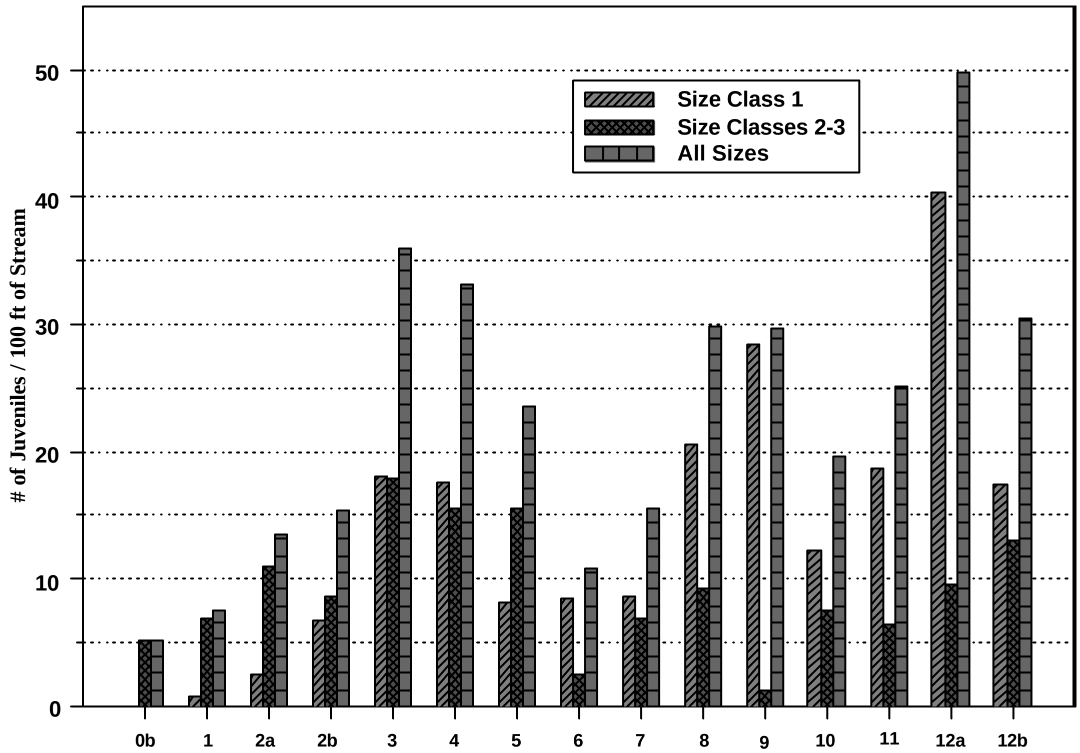
Reach #	Sampling Site # -Channel Mile	MAINSTEM SITES Location of Sampling Sites
0	0a –CM1.6	Above Water Street Bridge
0	0b –CM2.3	Above Highway 1 Bridge
1	1 -CM3.8	Paradise Park
2	2 -CM5.7	Lower Gorge at Rincon Trail Access
3	3 -CM7.4	Upper End of the Gorge
4	4 -CM8.9	Downstream of the Cowell Park Entrance Bridge
5	5 -CM9.3	Downstream of Zayante Creek Confluence
6	6 -CM10.4	Below Fall Creek Confluence
7	7 -CM13.8	Above Lower Highway 9 Crossing in Ben Lomond
8	8 -CM15.9	Upstream of the Larkspur Road (Brookdale)
9	9 -CM18.0	Downstream of Boulder Creek Confluence
10	10 -CM20.7	Below Kings Creek Confluence
11	11 -CM22.3	Downstream of Teilh Road, Riverside Grove
12	12a-CM24.7	Downstream of Waterman Gap and Highway 9
	12b-CM25.4	Waterman Gap Upstream of Highway 9

Table 1c. Sampling Sites Used to Estimate Densities of Steelhead by Reach (Cont'd) on the Mainstem San Lorenzo River and Tributaries, 2001.

Reach #	Sampling Site # -Channel Mile	TRIBUTARY SITES Location of Sampling Sites
13a	13a-CM0.3	Zayante Creek Upstream of Conference Drive Bridge
13b	13b-CM1.6	Zayante Creek Above First Zayante Rd Xing
13c	13c-CM2.8	Zayante Creek downstream of Zayante School Road Intersection with E. Zayante Road
13d	13d-CM4.1	Zayante Creek upstream of Third Bridge Crossing of East Zayante Road After Lompico Creek Confluence
14a	14a-CM0.1	Bean Creek Upstream of Zayante Creek Confluence
14b	14b-CM1.8	Bean Creek Below Lockhart Gulch Road
14c	14c-CM4.5	Bean Creek 1/4-mile Above Mackenzie Creek Confluence and Below Golpher Gulch Rd.
15	15 -CM0.8	Fall Creek, Above and Below Wooden Bridge
16	16 -CM0.5	Newell Creek, Upstream of Glen Arbor Road Bridge
17a	17a-CM0.2	Boulder Creek Just Upstream of Highway 9
17b	17b-CM1.6	Boulder Creek Below Bracken Brae Creek Confluence
17c	17c-CM2.6	Boulder Creek, Downstream of Jamison Creek
18a	18a-CM1.5	Bear Creek, Just Upstream of Hopkins Gulch
18b	18b-CM4.2	Bear Creek, Downstream of Bear Creek Road Bridge and Deer Creek Confluence
19a	19a-CM0.8	Kings Creek, Upstream of First Kings Creek Road Bridge
19b	19b-CM2.5	Kings Creek, 0.2 miles Above Boy Scout Camp and Upstream of the Second Kings Creek Road Bridge
20a	20a-CM0.7	Carbonera Creek, Upstream of Health Services Complex
20b	20b-CM1.9	Downstream of Buelah Park Trail
21a	21a-CM2.8	Branciforte Creek, Downstream of Granite Creek Confluence
21b	21b-CM4.6	Upstream of Granite Creek Confluence and Happy Valley School

FIGURES

Figure 1. Juvenile Steelhead Densities of SIZE CLASSES at Mainstem San Lorenzo River SITES in 2001.



Sampling Site Corresponding to Table 1.

Figure 2. Juvenile Steelhead Densities of SIZE CLASSES at Tributary SITES in 2001.

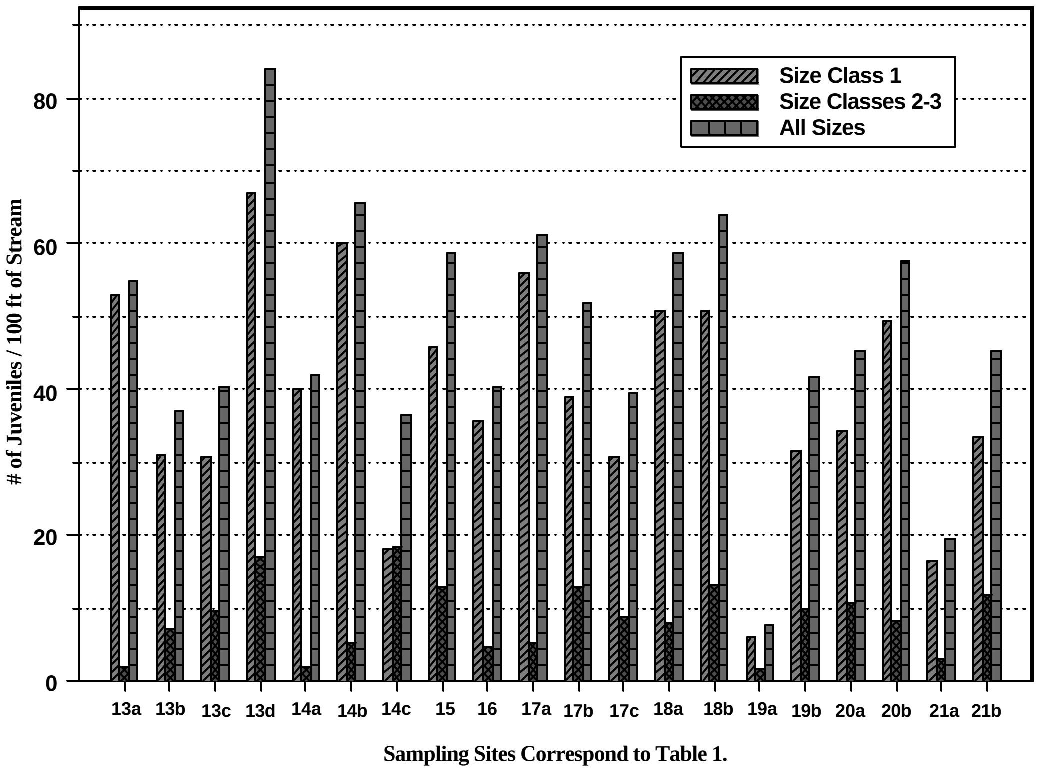


Figure 3. Juvenile Steelhead Densities at Comparable Mainstem and Tributary Sites for Size Class 1, 1997-2001.

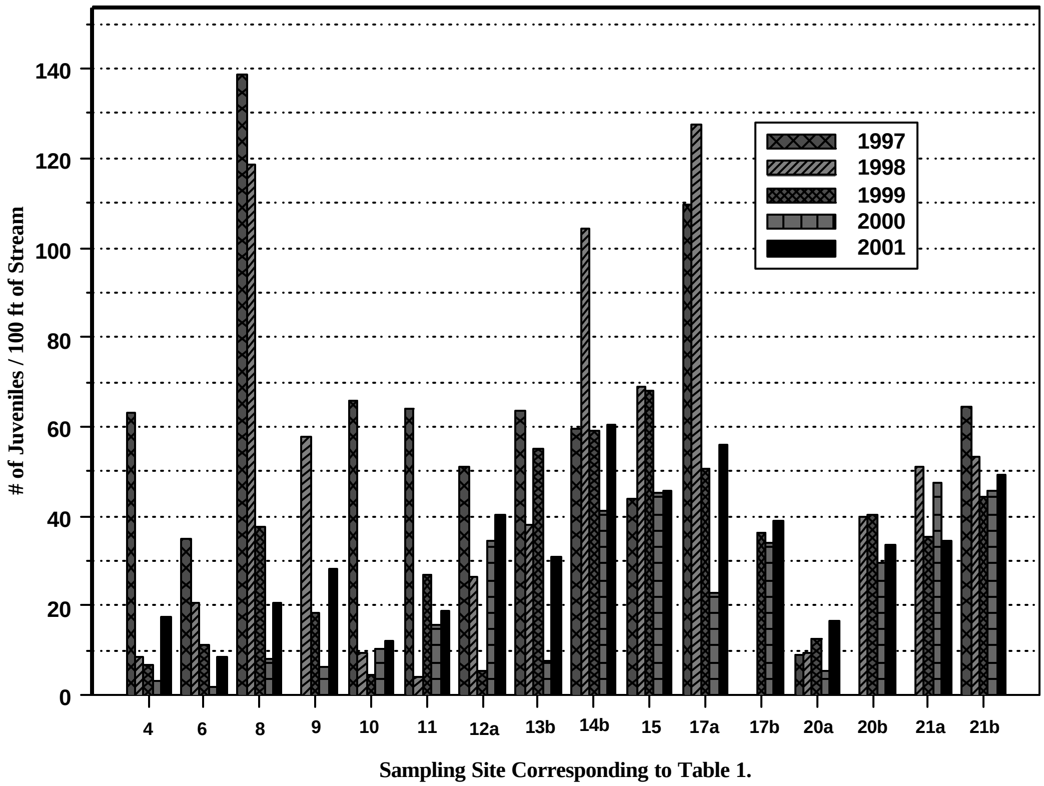


Figure 4. Juvenile Steelhead Densities at Comparable Mainstem and Tributary Sites for Size Classes 2 and 3 in 1997-2001.

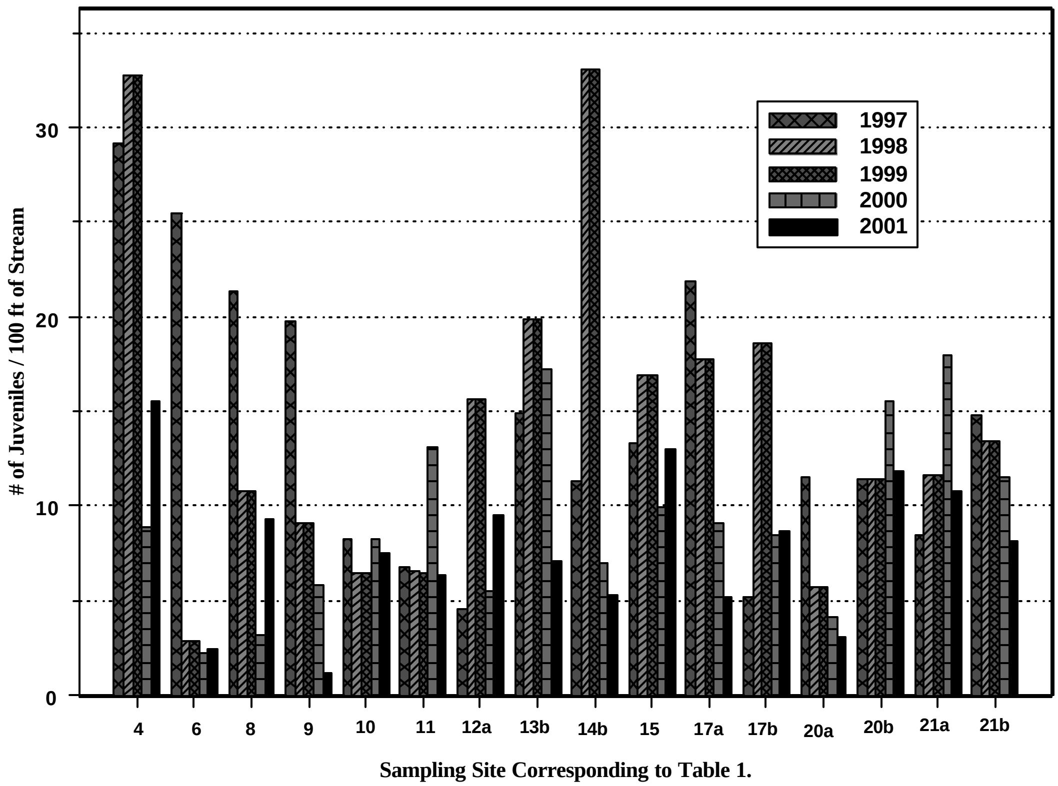


Figure 5. Trend in Average Tributary Site Density for Juvenile Steelhead in Zayante, Bean and Fall Creeks, 1970, 1981, 1989 and 1994-2001.

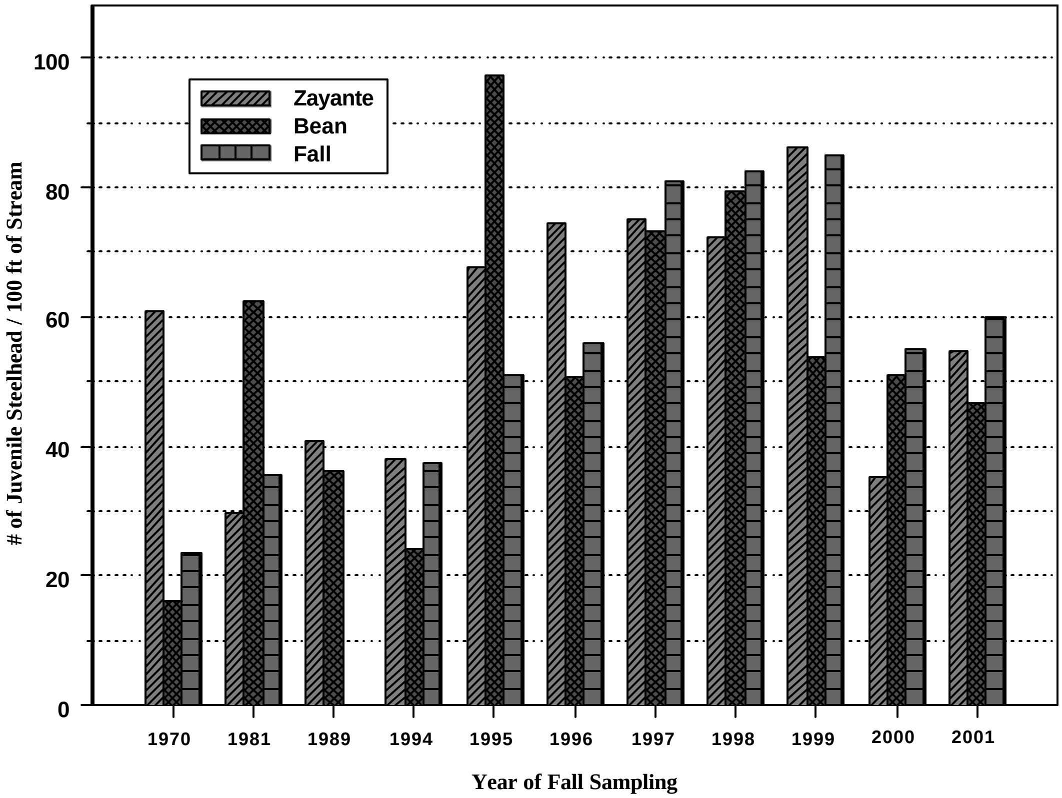


Figure 6. Juvenile Steelhead Densities of AGE CLASSES at Mainstem San Lorenzo River SITES, 2001.

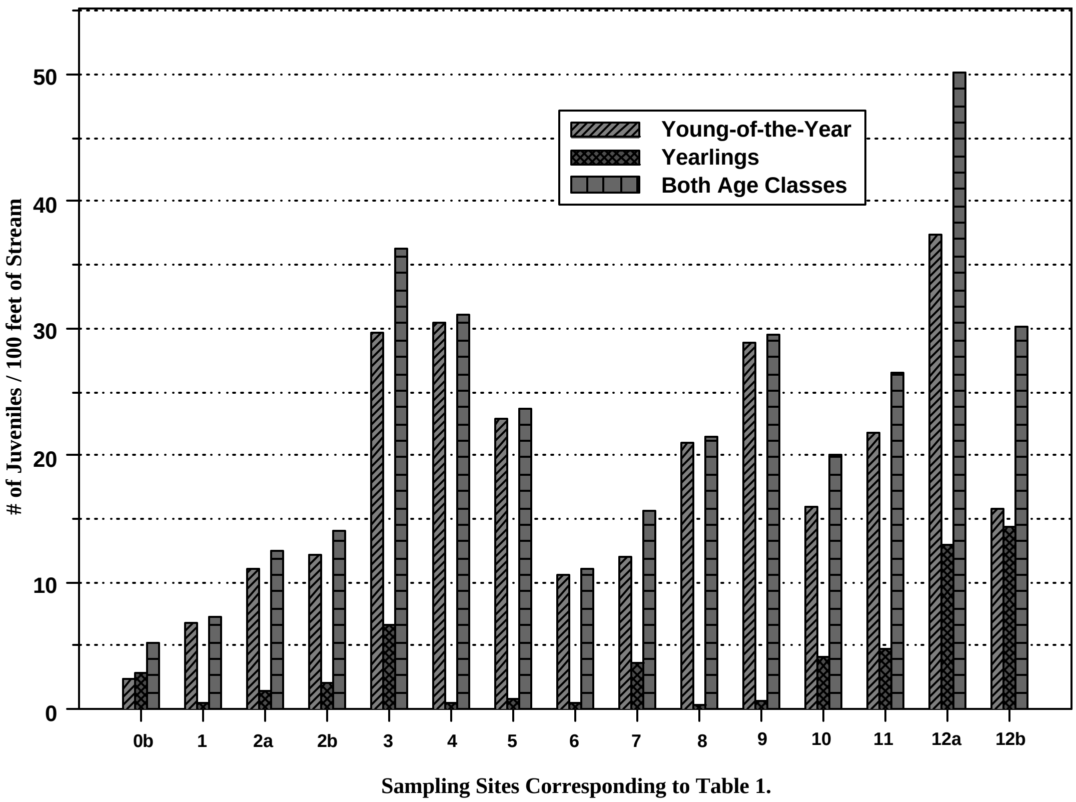
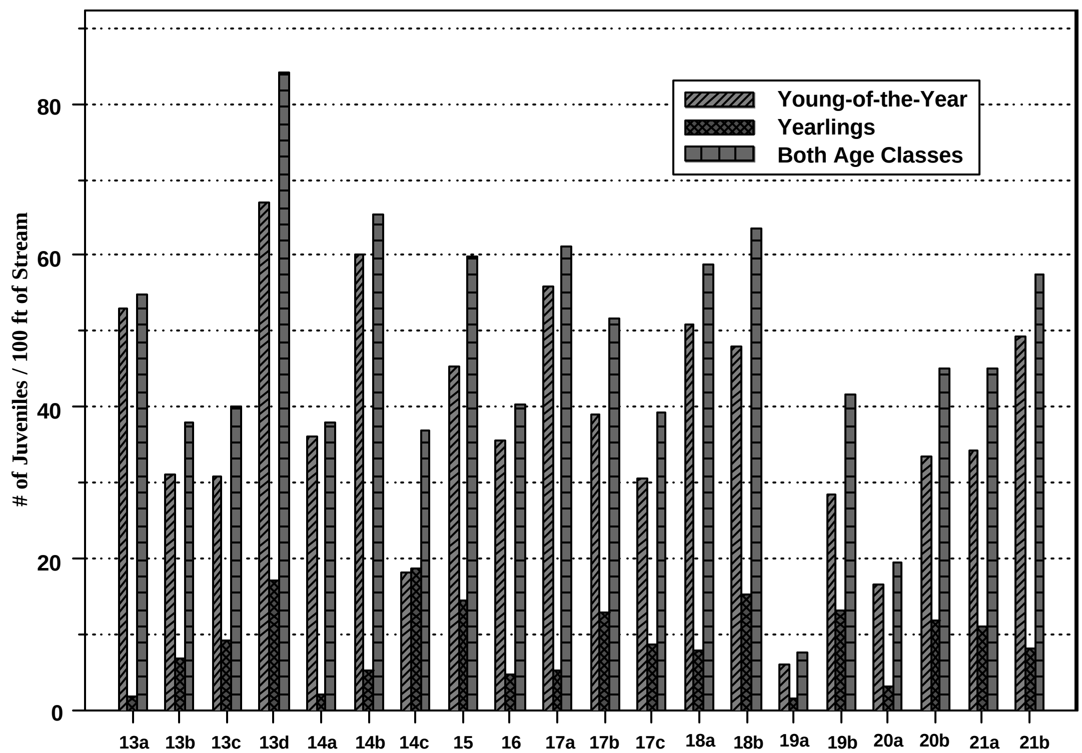


Figure 7. Juvenile Steelhead Densities of AGE CLASSES at Tributary SITES, 2001.



Sampling Sites Corresponding to Table 1.

Figure 8. Juvenile Steelhead Densities at Comparable Mainstem and Tributary Sites for the YOUNG-OF-THE-YEAR AGE CLASS, 1997-2001.

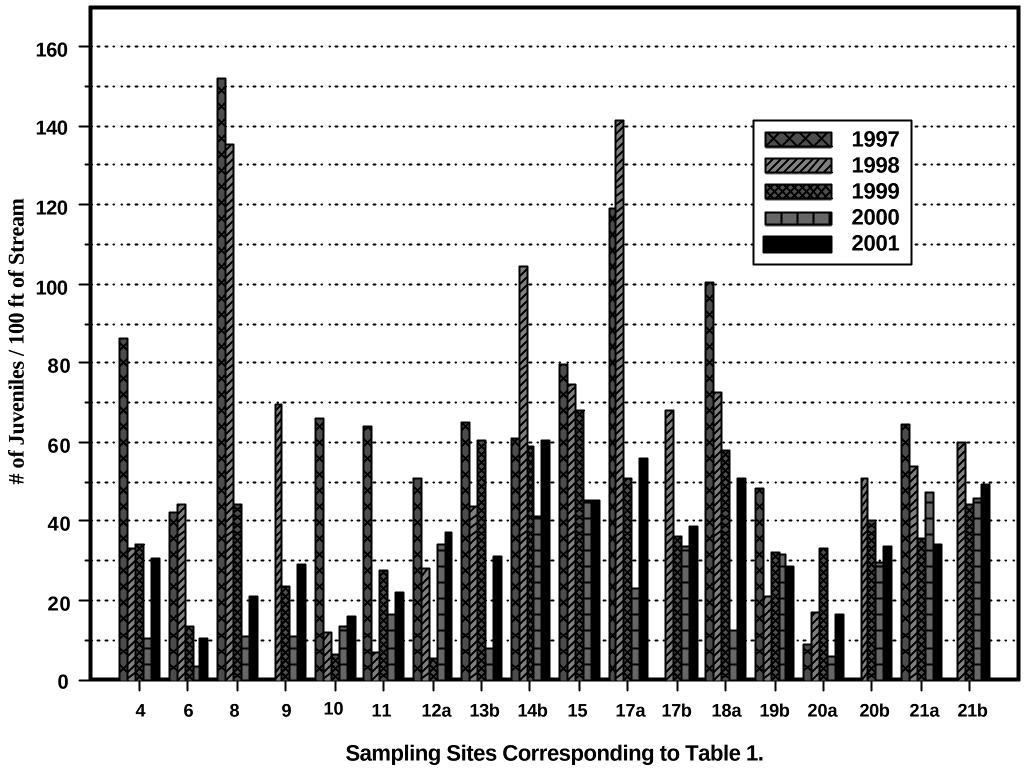


Figure 9. Juvenile Steelhead Densities at Comparable Mainstem and Tributary Sites for the YEARLING AGE CLASS, 1997-2001.

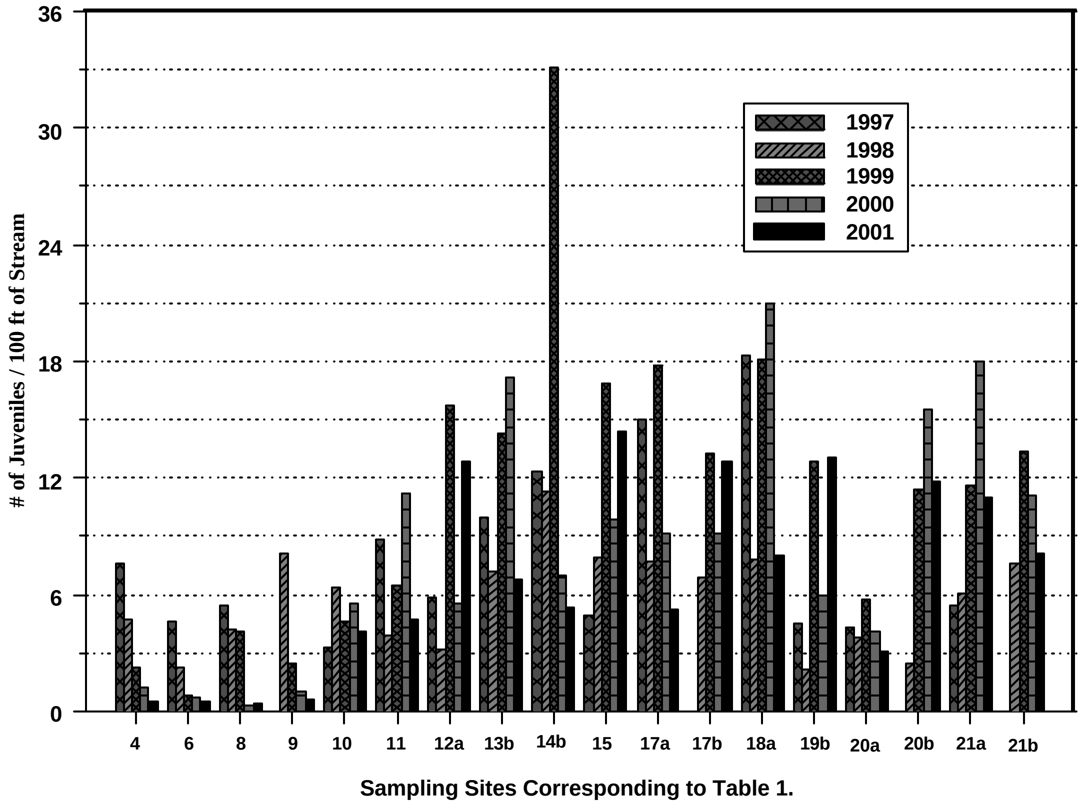


Figure 10. NUMBER of Juvenile Steelhead in the <75 mm SL Size Class BY REACH in the Mainstem San Lorenzo River in 1996-2001.

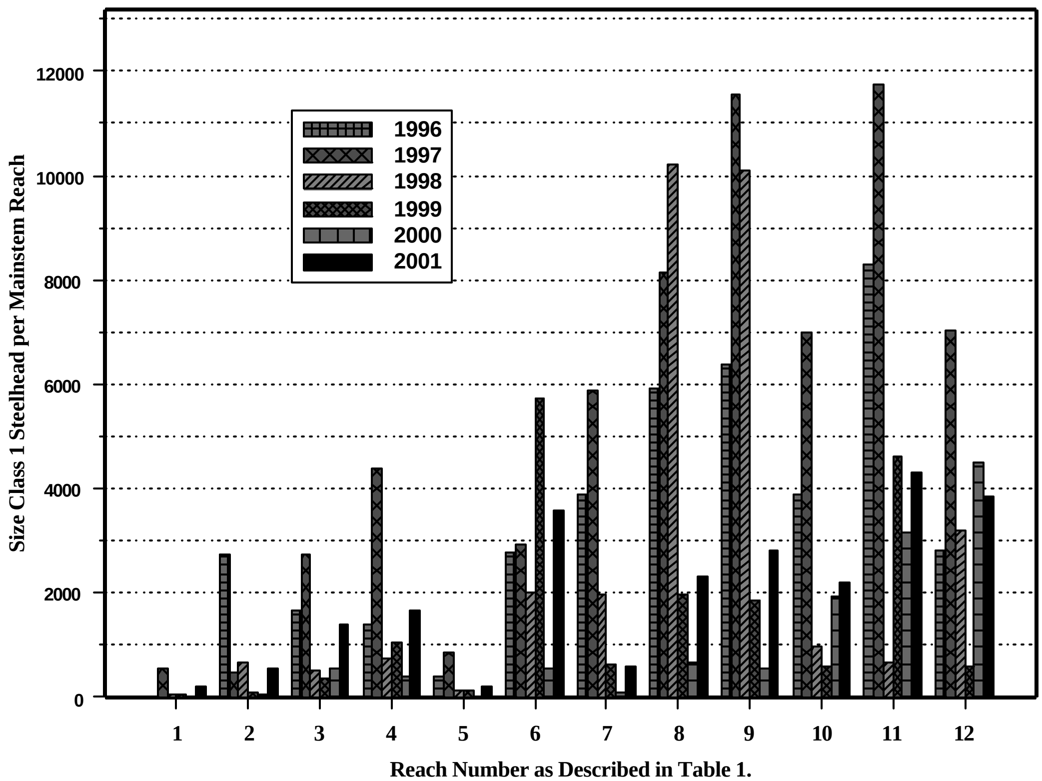


Figure 11. NUMBER of YOUNG-OF-THE-YEAR Juvenile Steelhead by Reach in the MAINSTEM San Lorenzo River in 1997-2001.

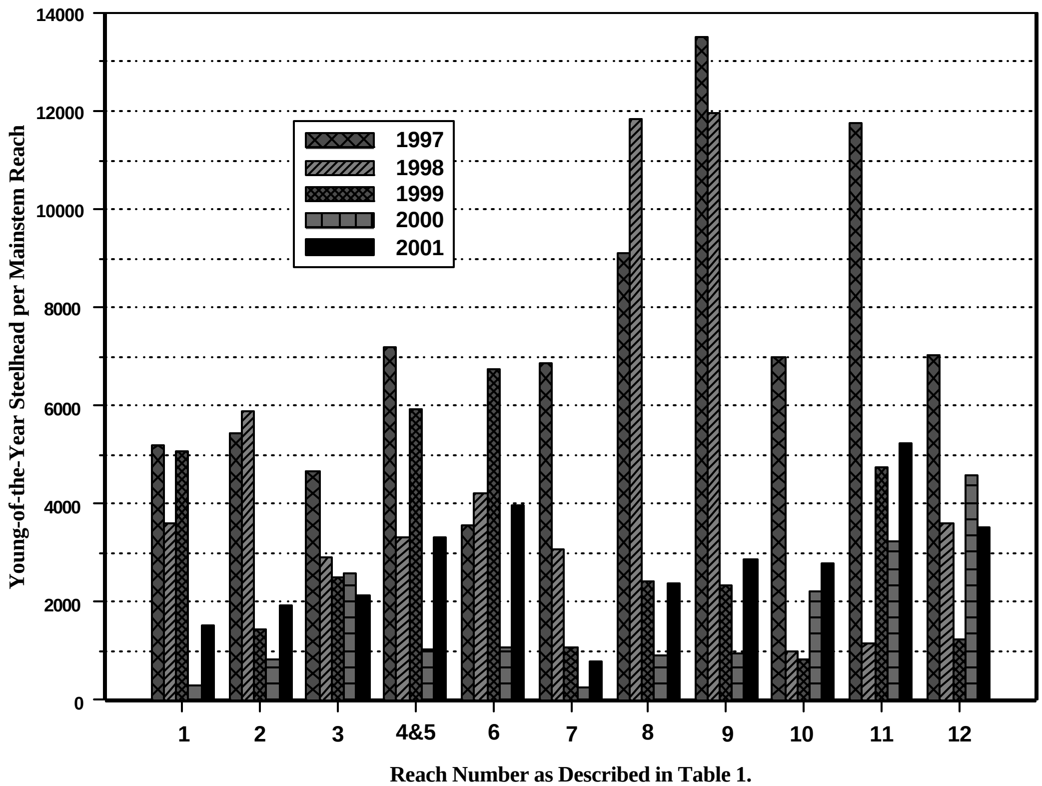


Figure 12. NUMBER of Juvenile Steelhead in SIZE CLASSES 2-3 (=>75 mm SL) BY REACH in the MAINSTEM San Lorenzo River in 1996-2001.

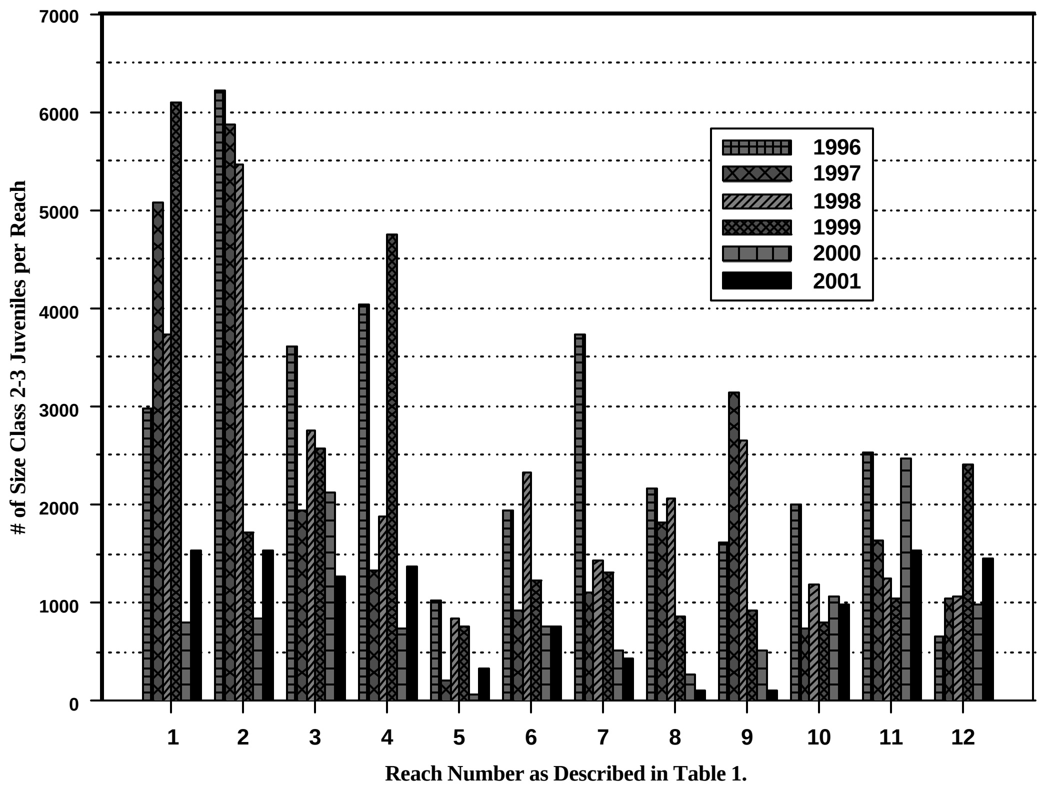


Figure 13. NUMBER of YEARLING Steelhead by REACH in the MAINSTEM San Lorenzo River in 1997-2001.

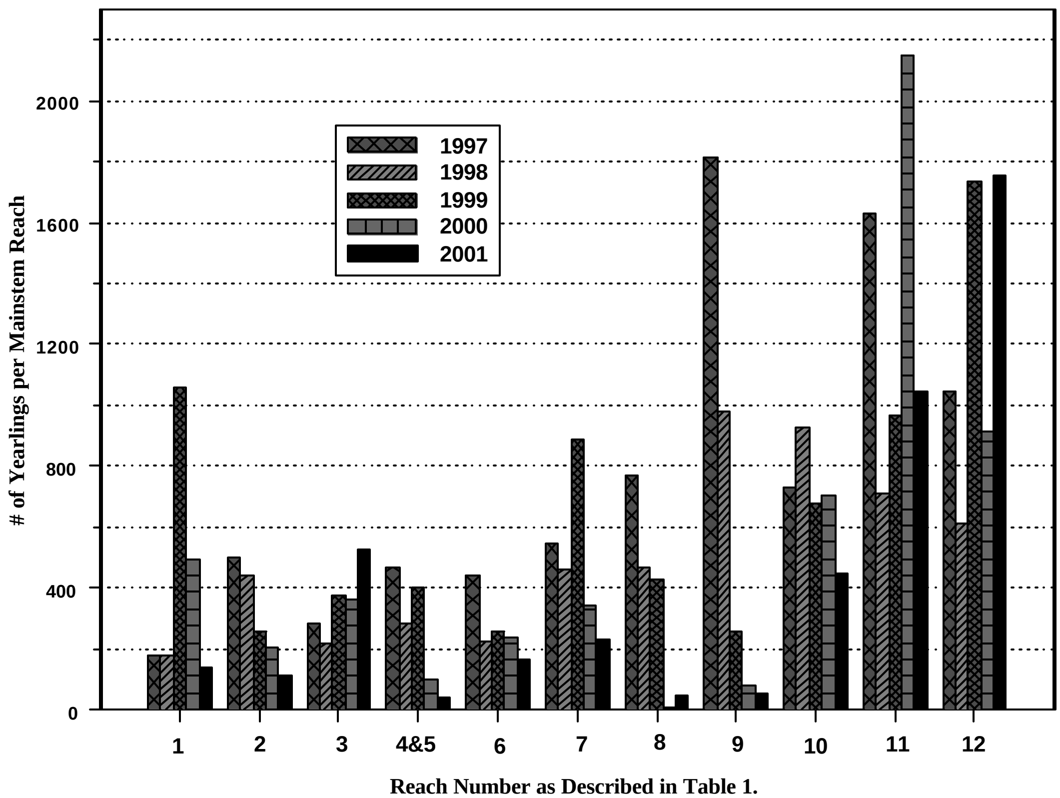


Figure 14. TOTAL NUMBER of Juvenile Steelhead BY REACH in the MAINSTEM San Lorenzo River in 1996-2001.

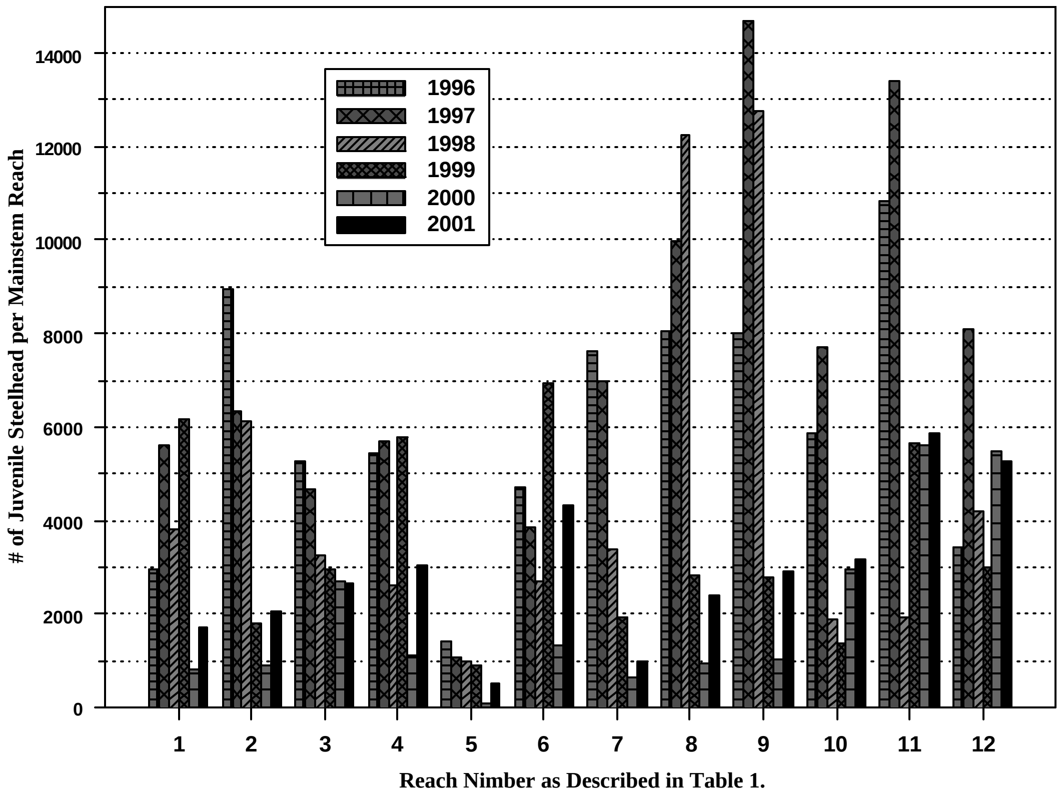


Figure 15. Number of YOUNG-OF-THE-YEAR Steelhead ACCUMULATED BY REACH in the San Lorenzo River Mainstem in 1997-2001.

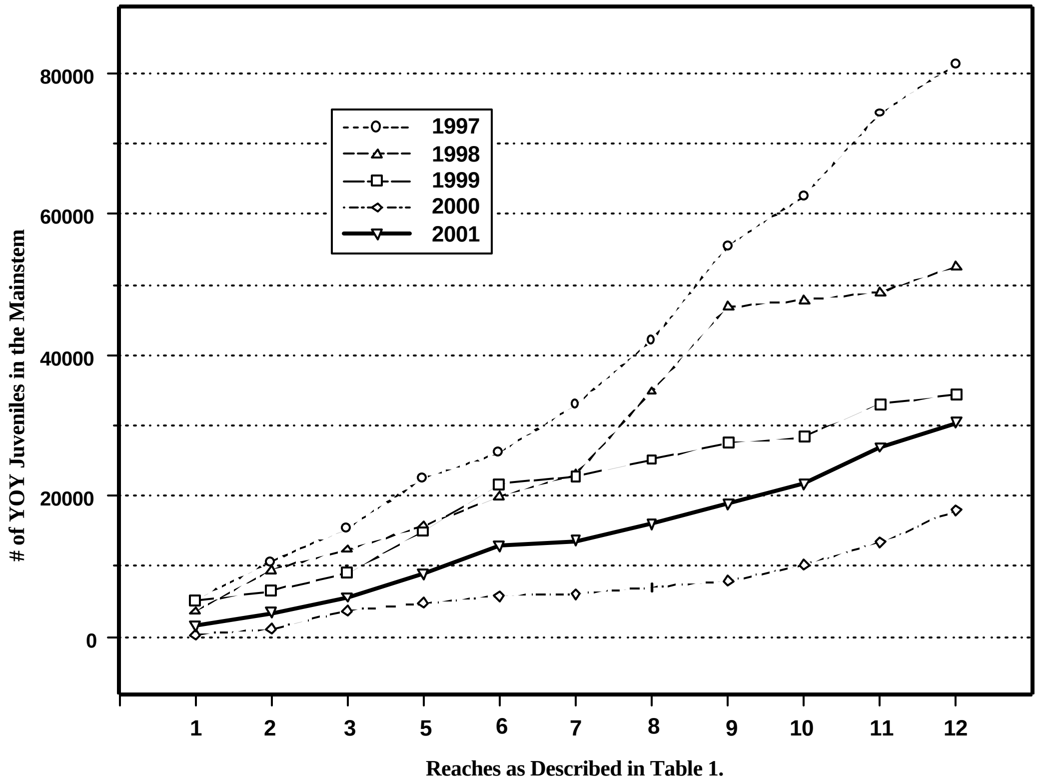


Figure 16. NUMBER of SIZE CLASS 2 AND 3 (=>75 mm SL) Juvenile Steelhead ACCUMULATED BY REACH in the San Lorenzo River Mainstem in 1997-2001.

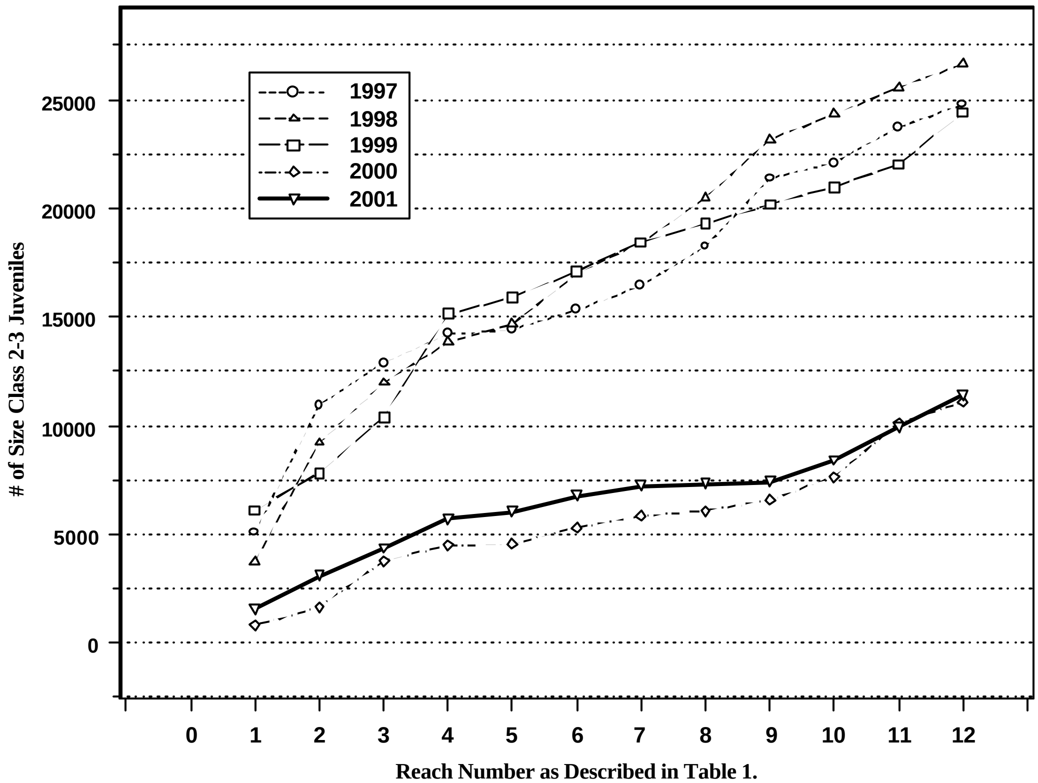


Figure 17. NUMBER of YEARLING Steelhead ACCUMULATED BY REACH in the San Lorenzo River Mainstem in 1997-2001.

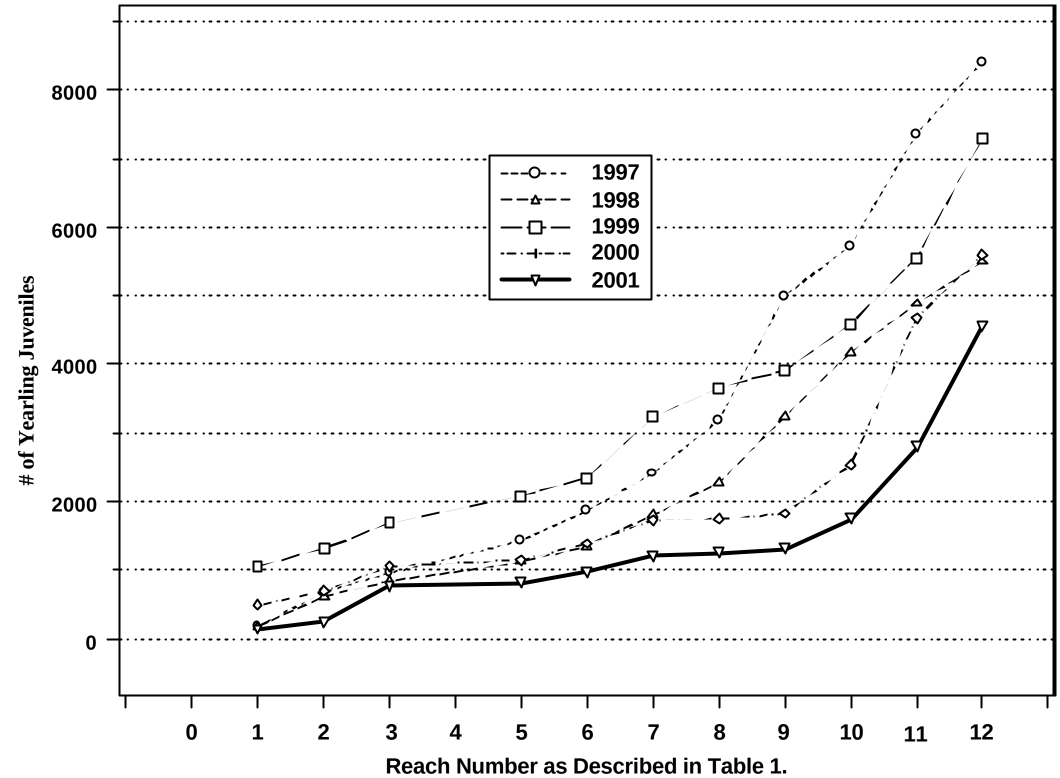


Figure 18. TOTAL NUMBER of Juvenile Steelhead ACCUMULATED BY REACH in the MAINSTEM San Lorenzo River in 1997-2001.

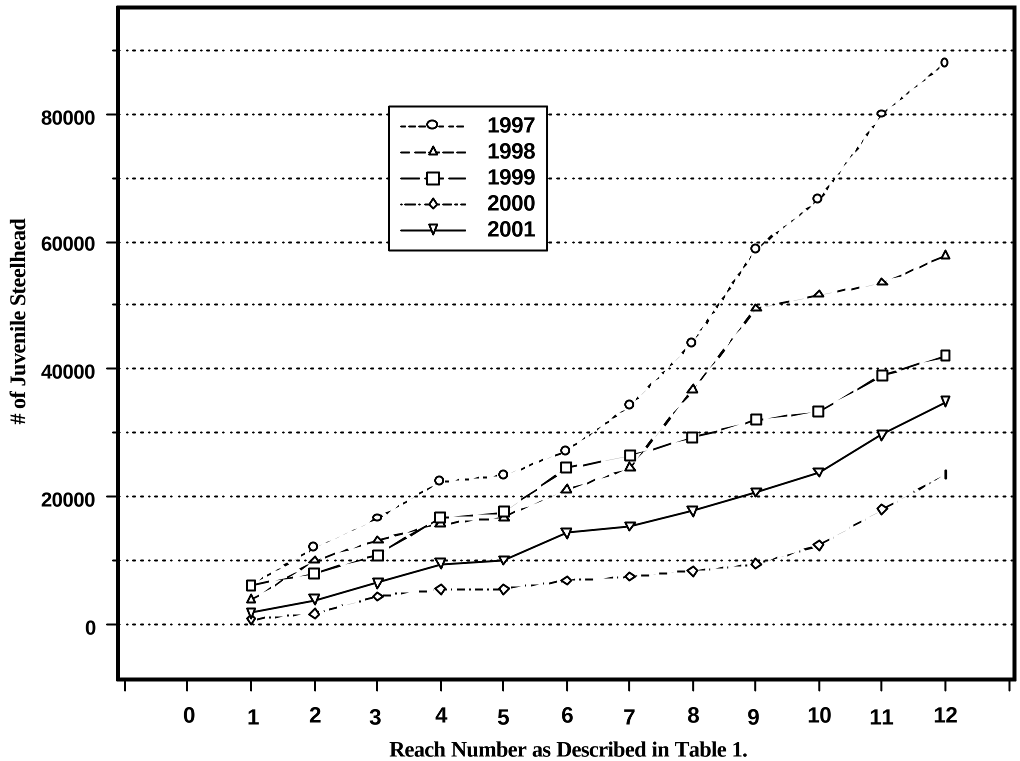


Figure 19. Production Estimates of Young-of-the-Year Steelhead in Major Tributaries to the San Lorenzo River in 1998-2001.

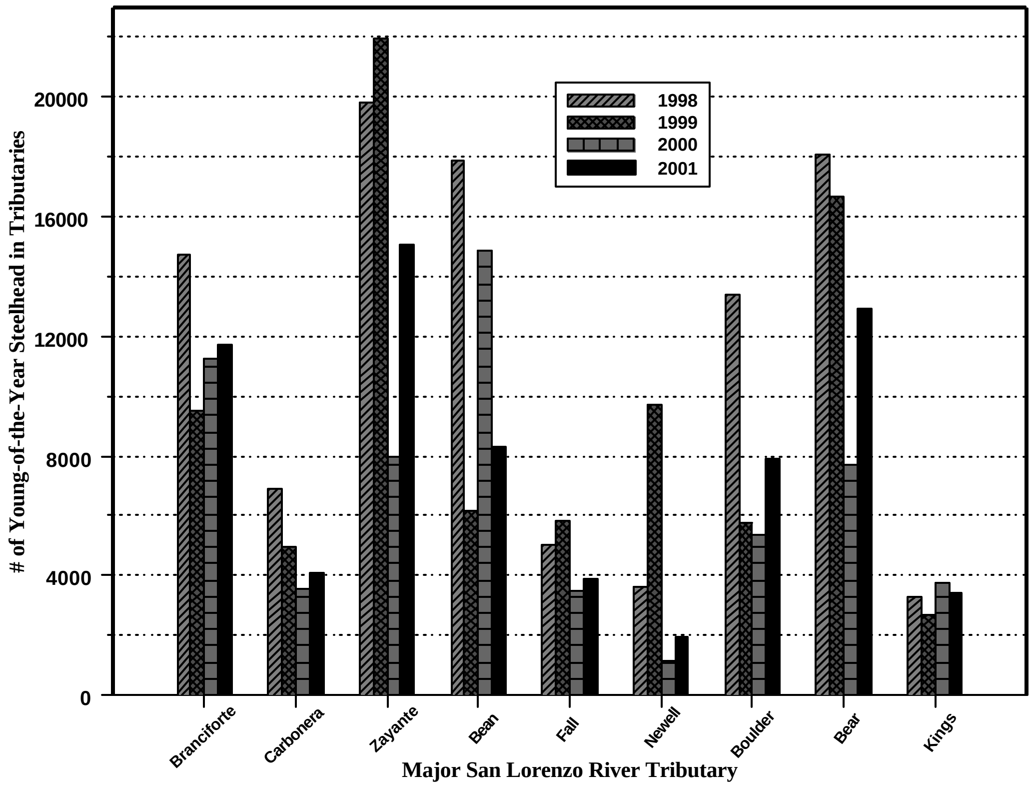


Figure 20a. Production Estimates of Yearling Steelhead in Major Tributaries to the San Lorenzo River in 1998-2001.

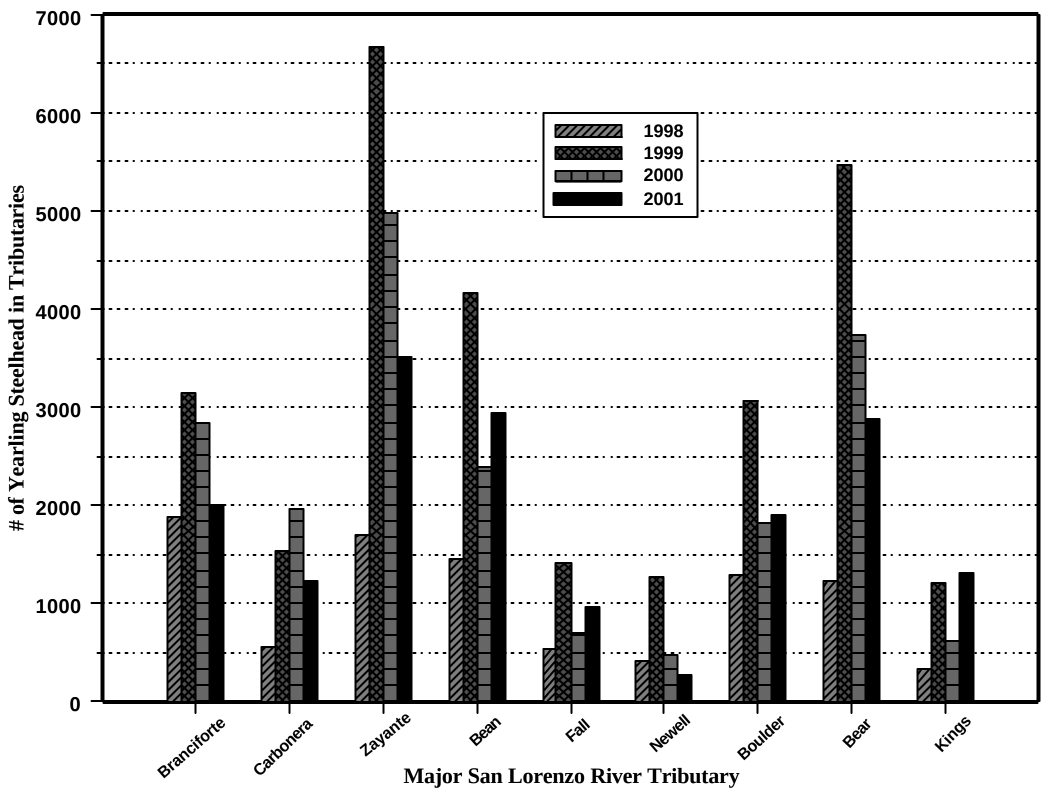


Figure 20b. Production Estimates of All Juvenile Steelhead in Major Tributaries to the San Lorenzo River in 1998-2001.

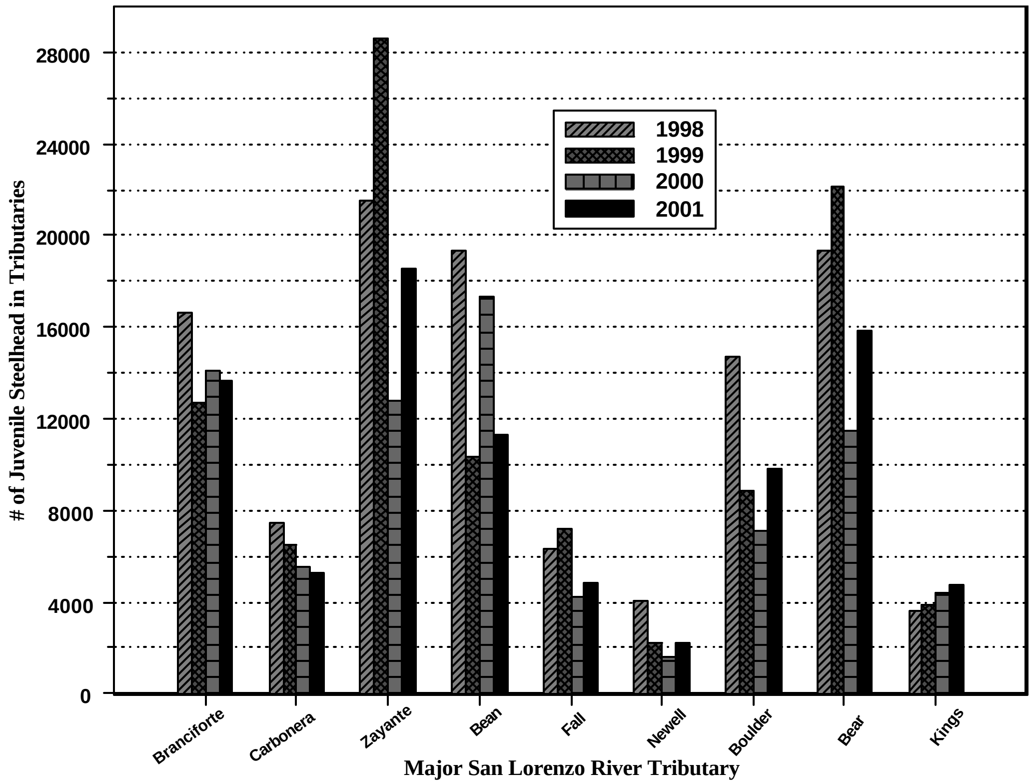


Figure 21a. Mainstem Juvenile Steelhead Estimates by Age Class in the San Lorenzo River in 1996-2001.

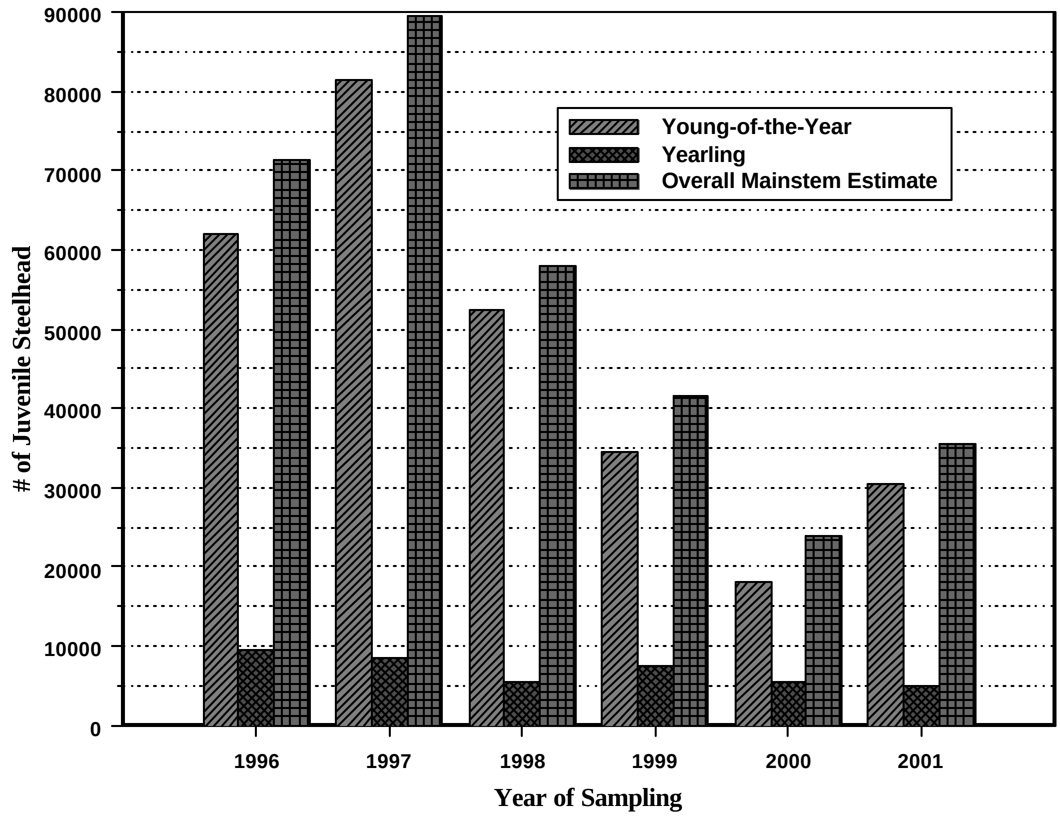


Figure 21b. Tributary Juvenile Steelhead Estimates by Age Class in the San Lorenzo River in 1998-2001.

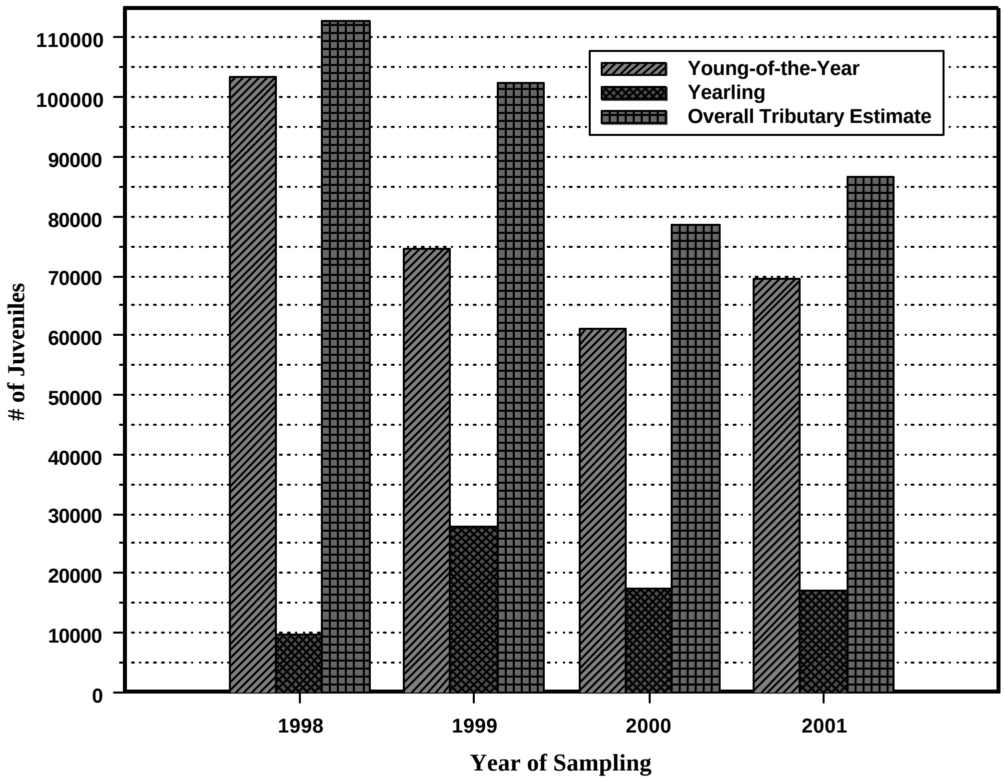


Figure 21c. Annual Juvenile Steelhead Estimates by Age Class for the Mainstem and Tributaries of the San Lorenzo River in 1998-2001.

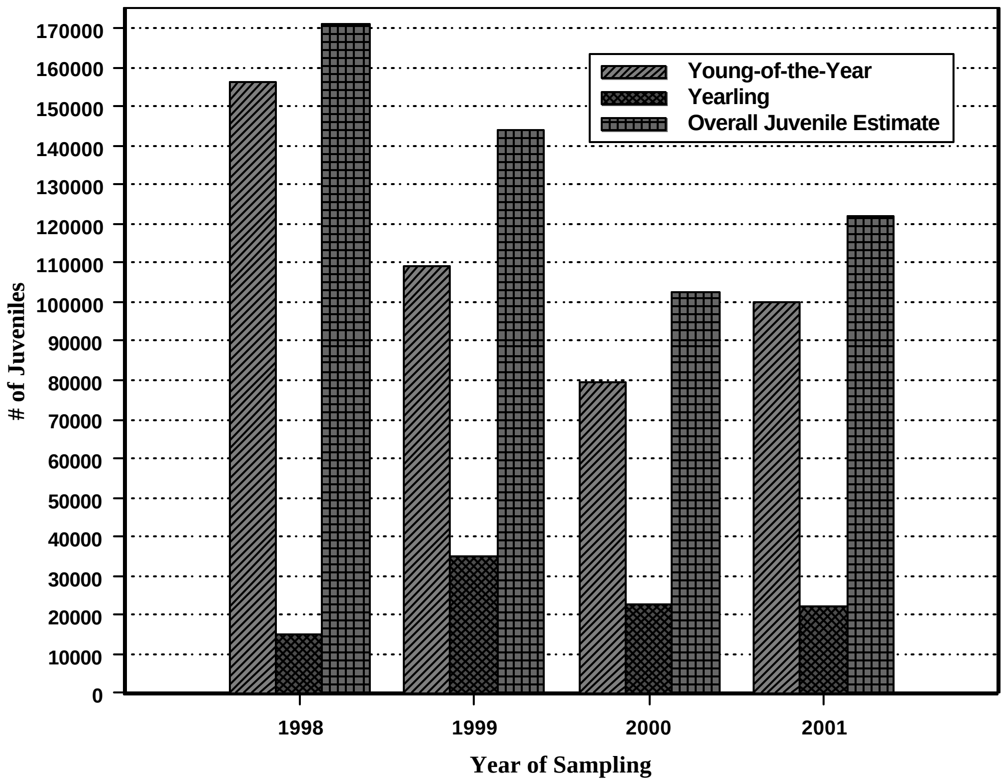


Figure 21d. MAINSTEM Juvenile Steelhead Estimates by SIZE CLASS in the San Lorenzo River in 1981 and 1994-2001.

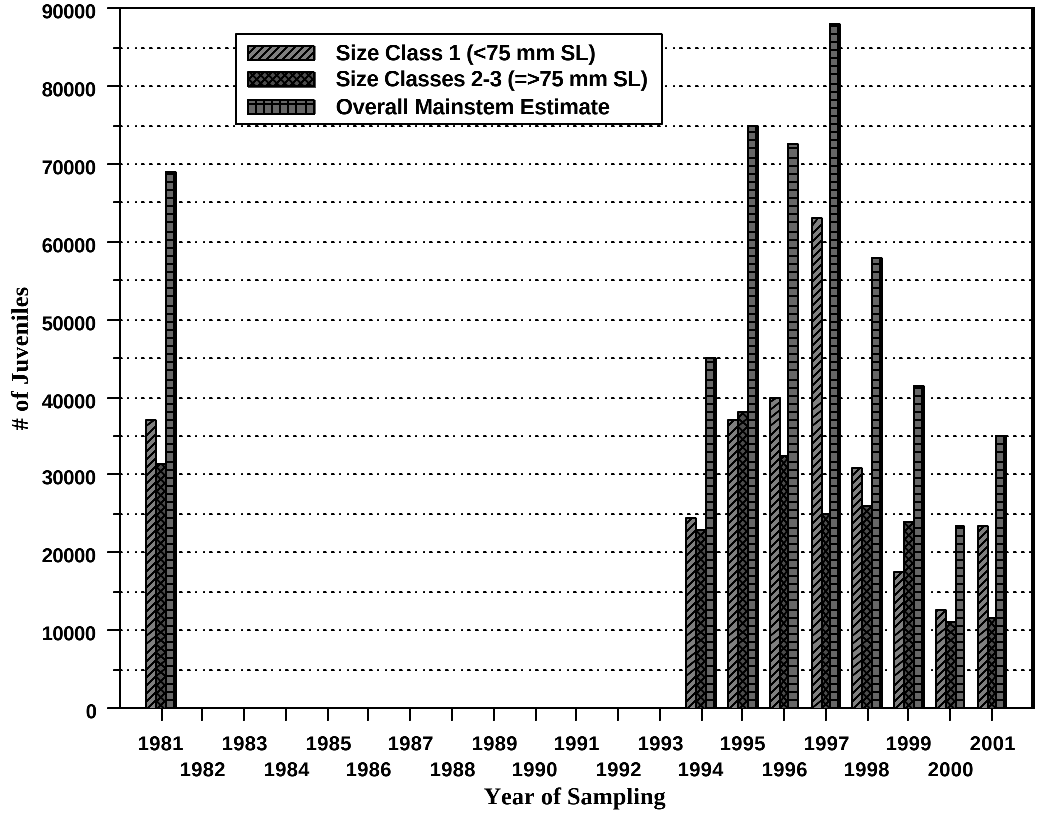


Figure 21e. TRIBUTARY Juvenile Steelhead Estimates by SIZE CLASS in the San Lorenzo River in 1998-2001.

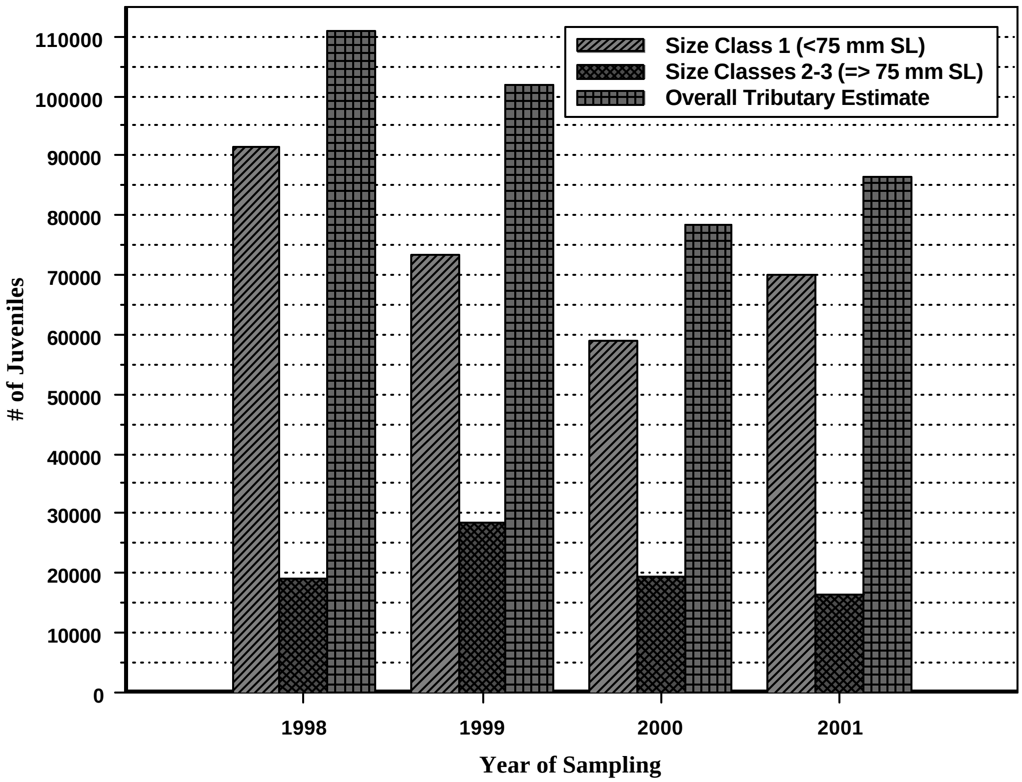


Figure 21f. Annual Juvenile Steelhead Estimates by SIZE CLASS in the San Lorenzo River in 1998-2001.

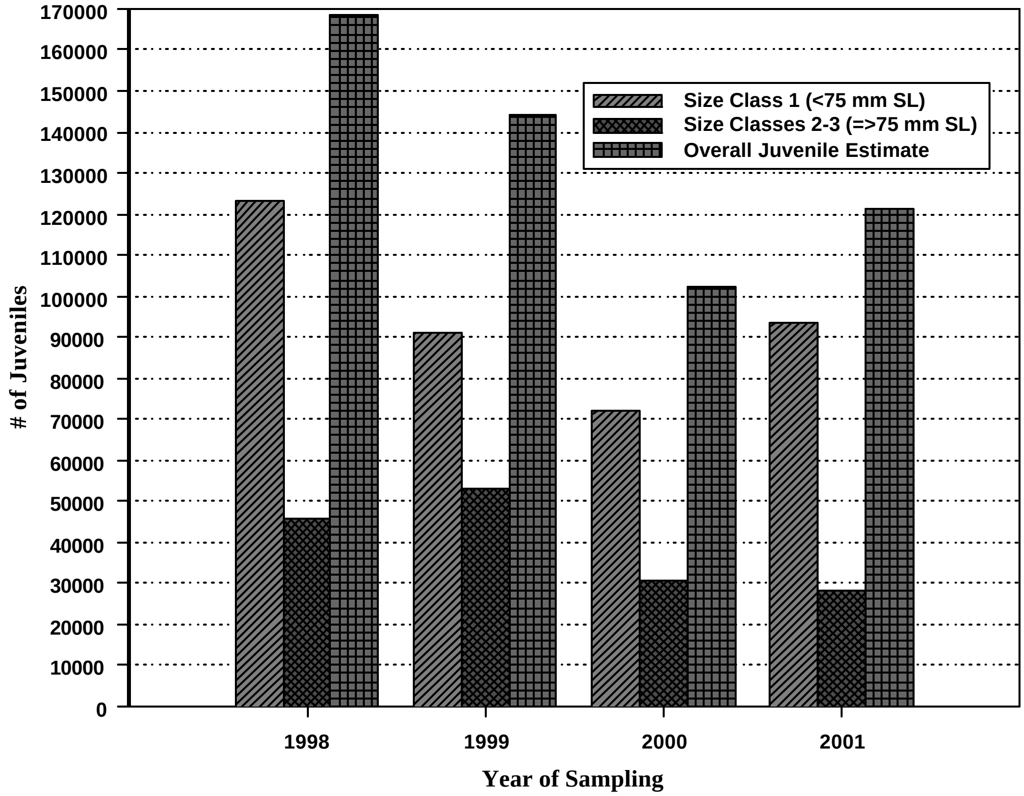


Figure 22a. Trends in the Index of Adult Steelhead Returns to the San Lorenzo River, Derived from Juvenile Production in 1981 and 1994-2001.

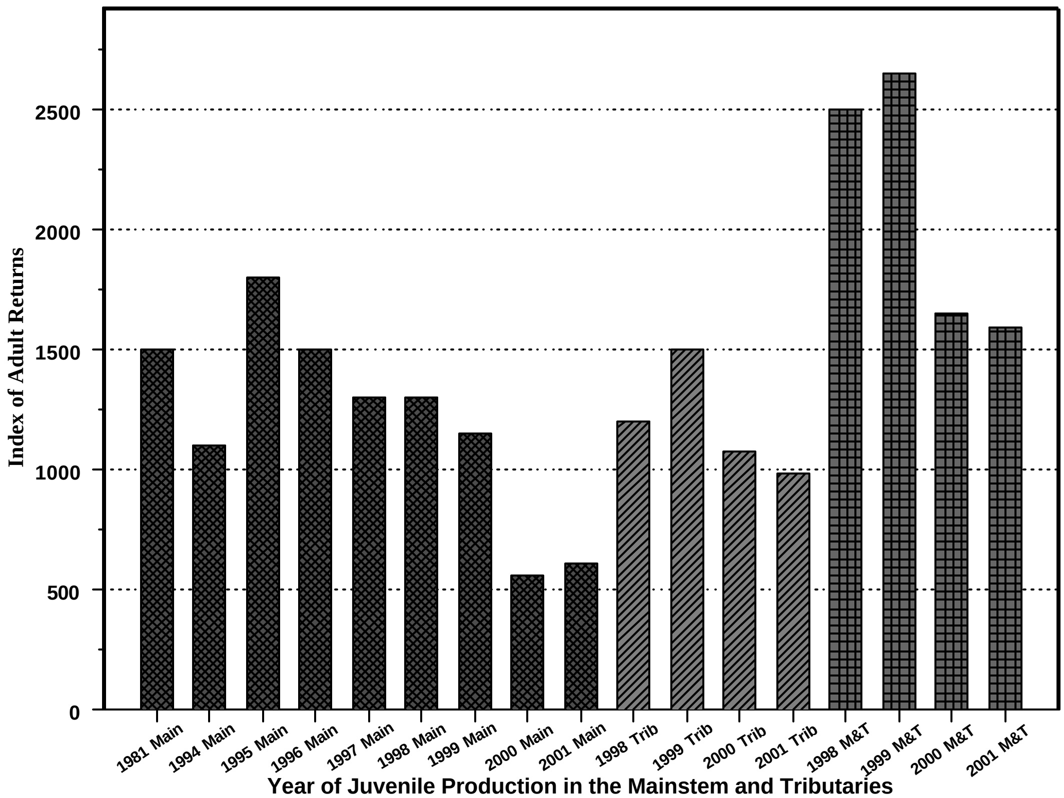


Figure 22b. Percent Contribution to the Adult Steelhead Index from Mainstem Segments and Nine Major Tributaries for 1998-2001. (Does not include Mainstem below Tait Street.)

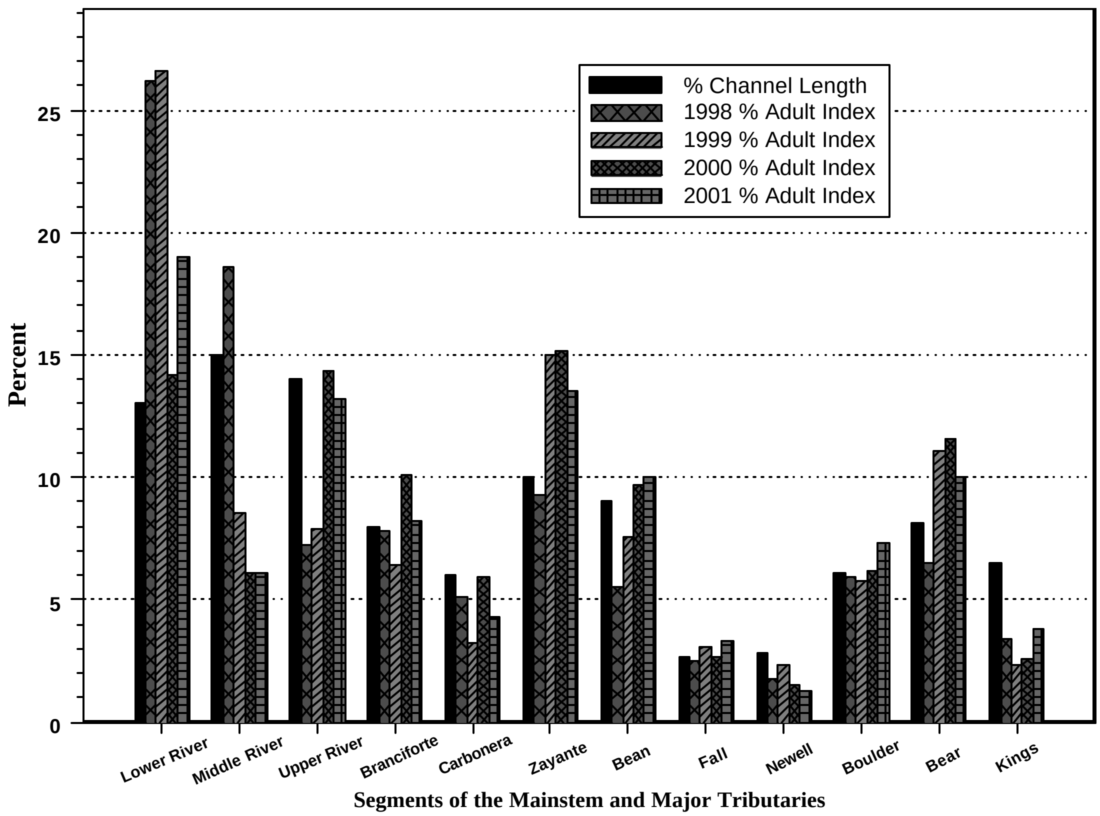


Figure 23. Average Embeddedness for Riffle and Flat-Water Habitat BY SITE in the Mainstem San Lorenzo River in 1997-2001.

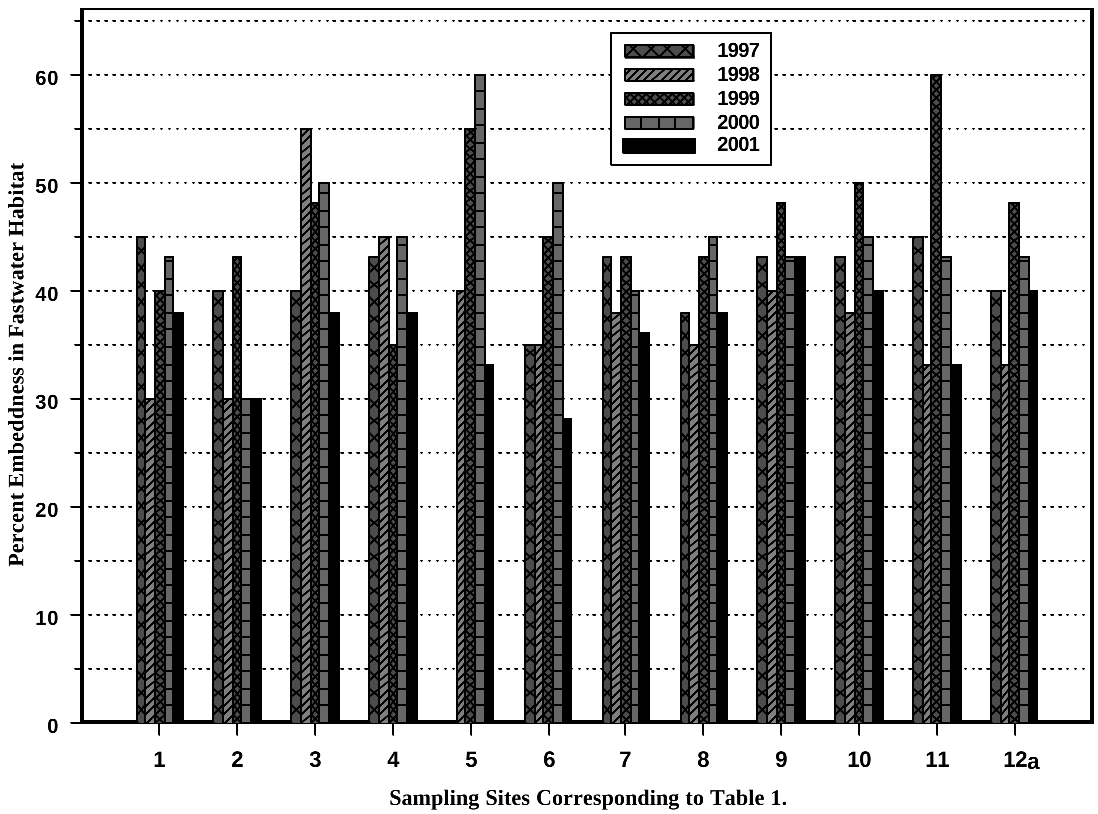


Figure 24. Average Embeddedness for Pools and Associated Glides at Mainstem River Sites in 1997-2001.

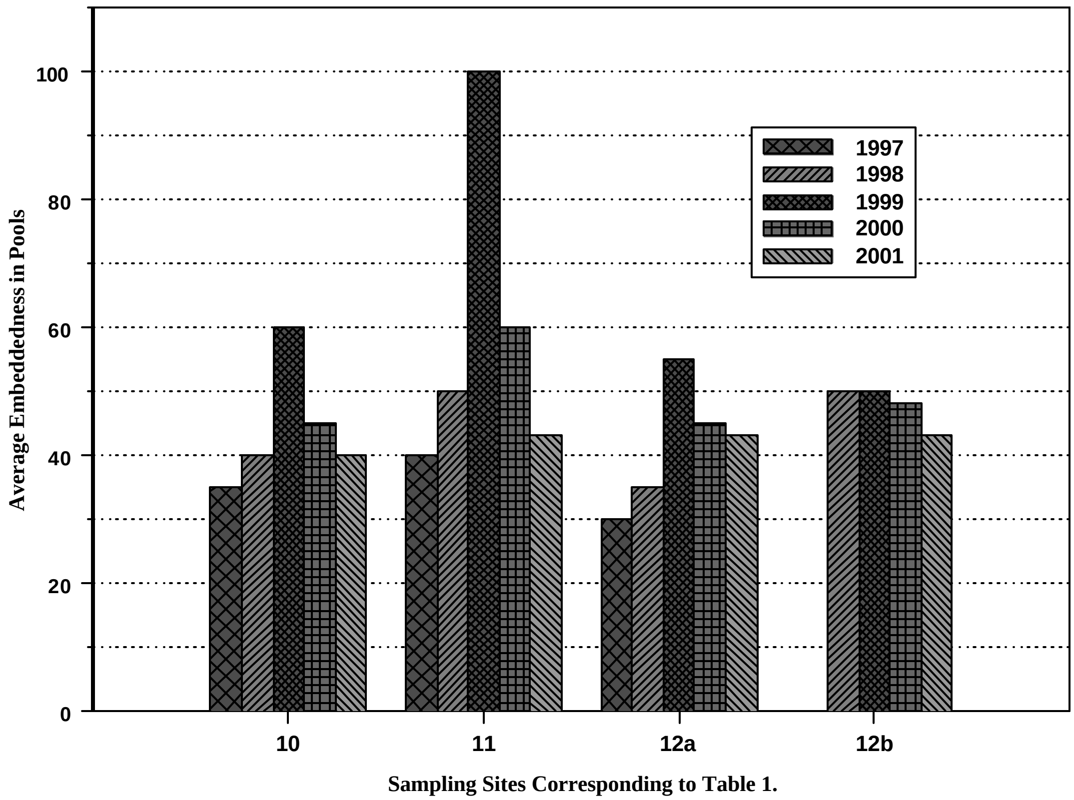


Figure 25a. Escape Cover Index (Perimeter Method) in Pools at Mainstem Sampling Sites in the San Lorenzo River in 1997-2001.

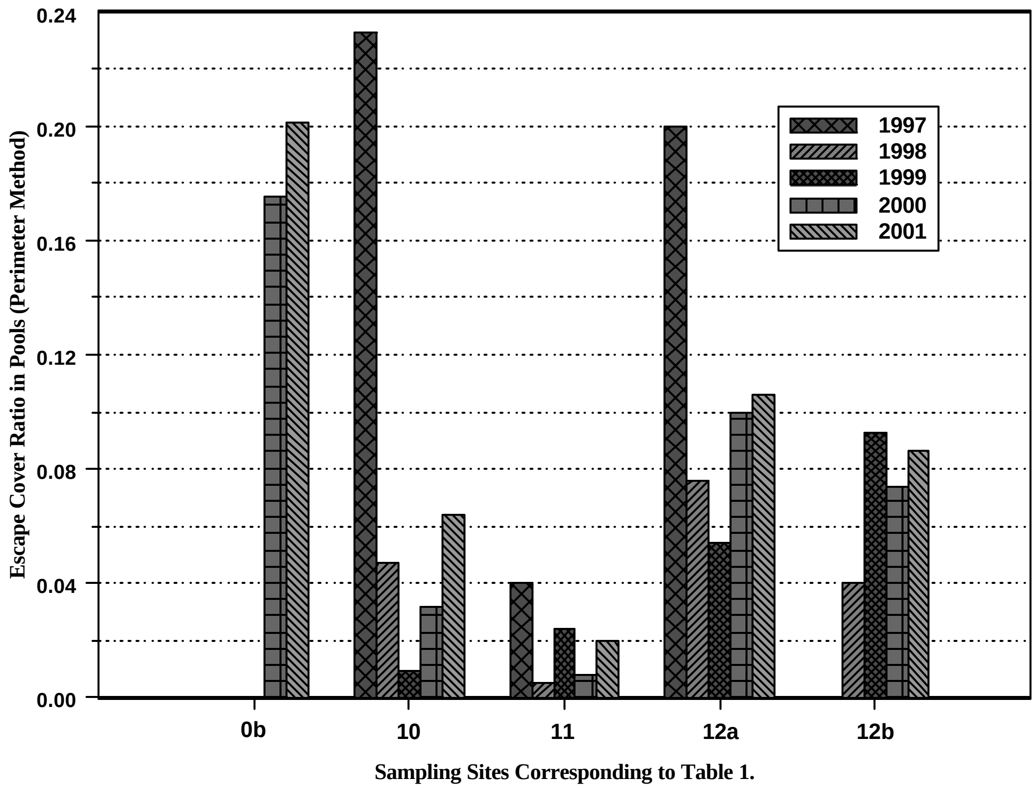


Figure 25b. Escape Cover Index (Perimeter Method) in Riffles at Mainstem Sampling Sites in the San Lorenzo River in 1997-2001.

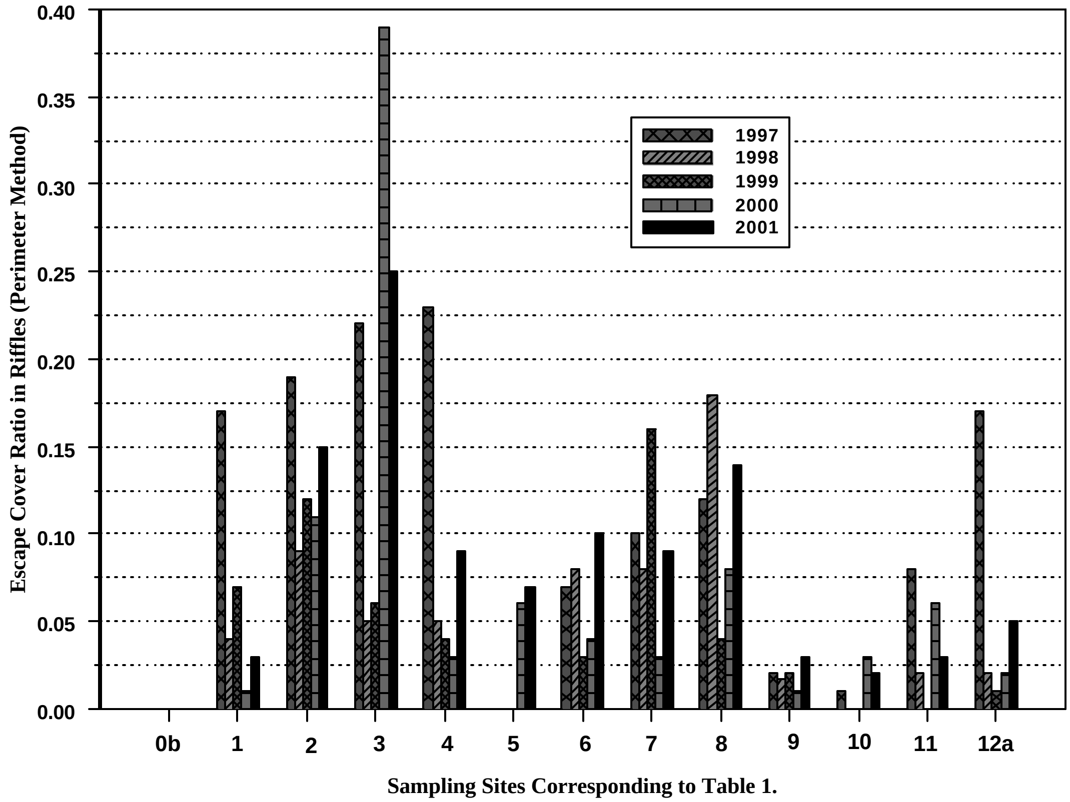
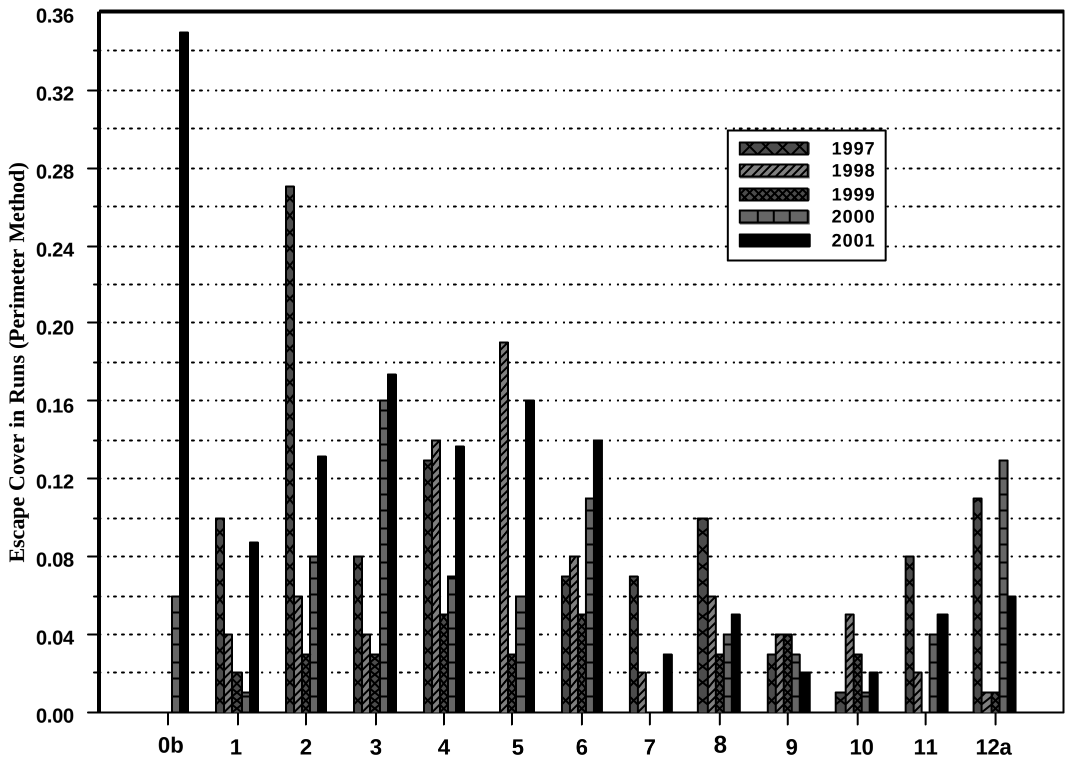


Figure 26. Escape Cover Index (Perimeter Method) for Run Habitat in Mainstem San Lorenzo River Sites in 1997-2001.



Sampling Sites Corresponding to Table 1.

Figure 27. Mean Depth in Riffles at Sampling Sites in the Mainstem San Lorenzo River in 2000 and 2001.

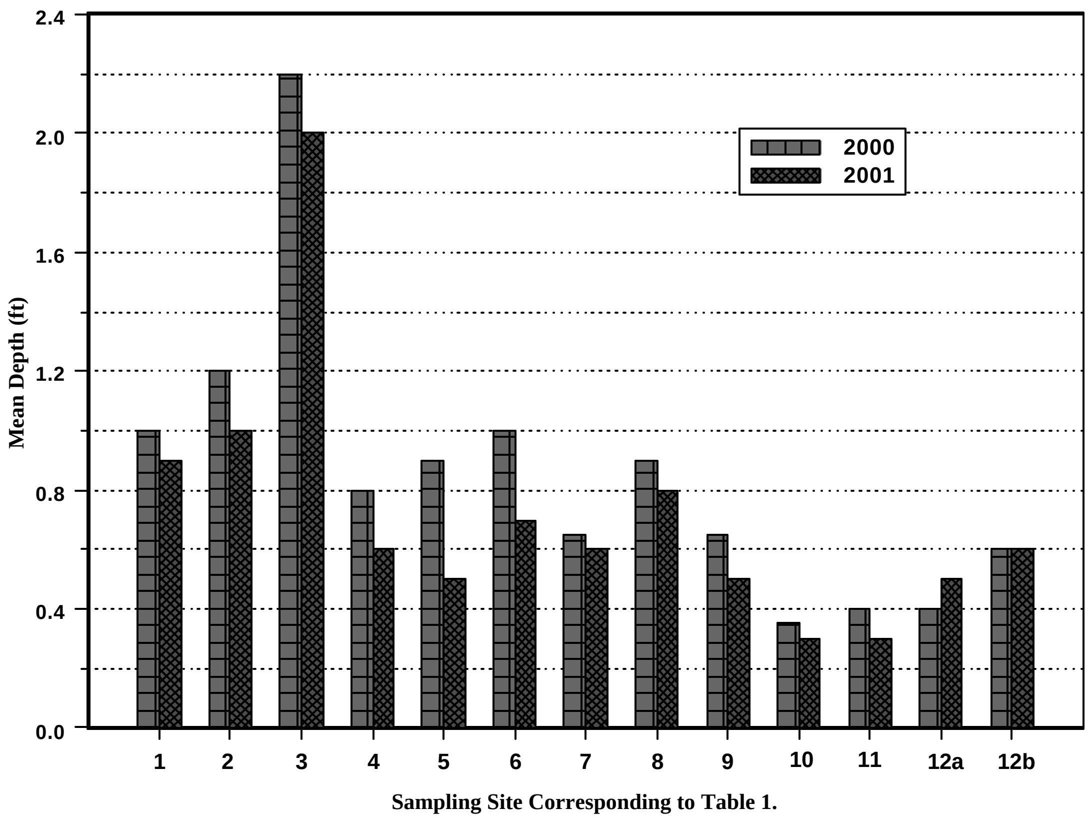


Figure 28. Mean Depth in Runs at Sampling Sites in the Mainstem San Lorenzo River in 2000 and 2001.

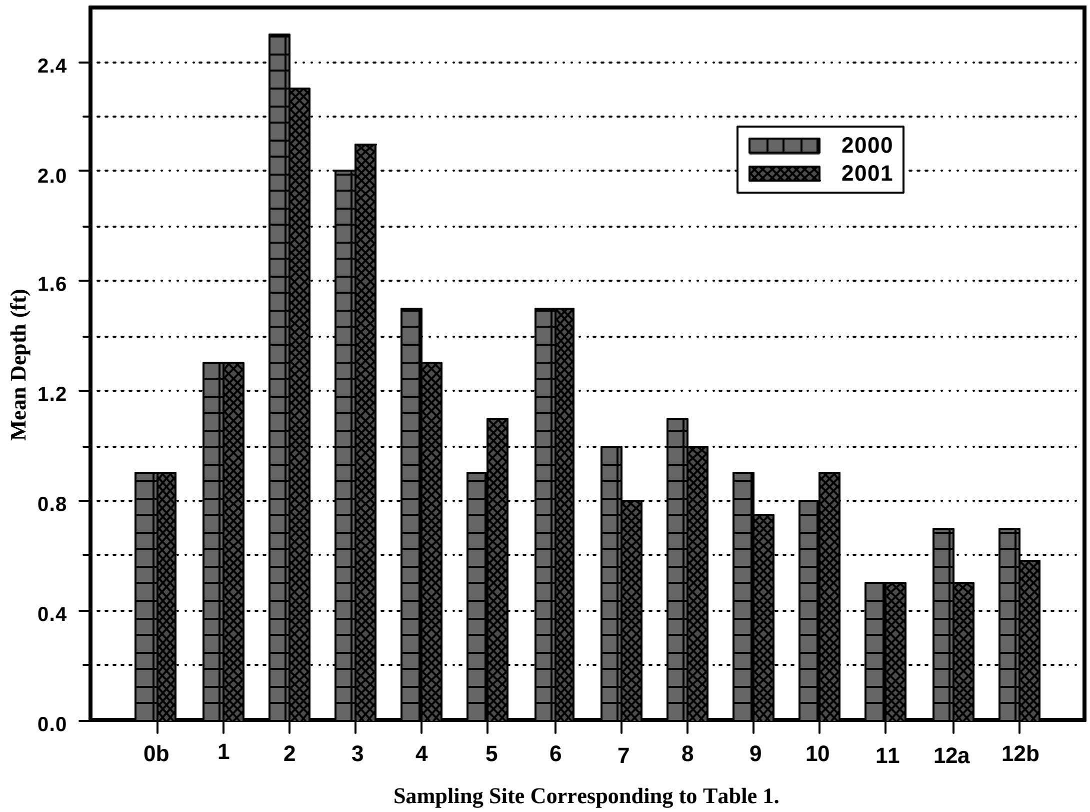


Figure 29. Mean and Maximum Depth in Pools at Sampling Sites in the Upper Mainstem San Lorenzo River in 2000 and 2001.

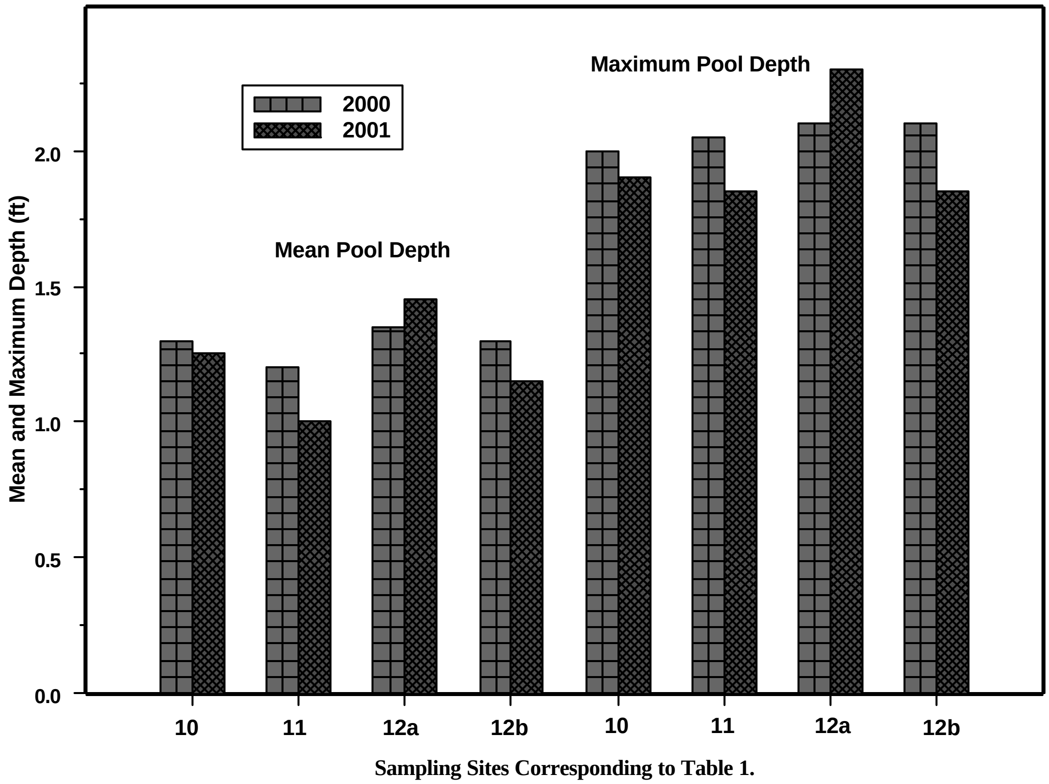


Figure 30a. Average Percent Embeddedness in Riffle and Run (Fastwater) Habitat at Tributary Sites in 2000 and 2001.

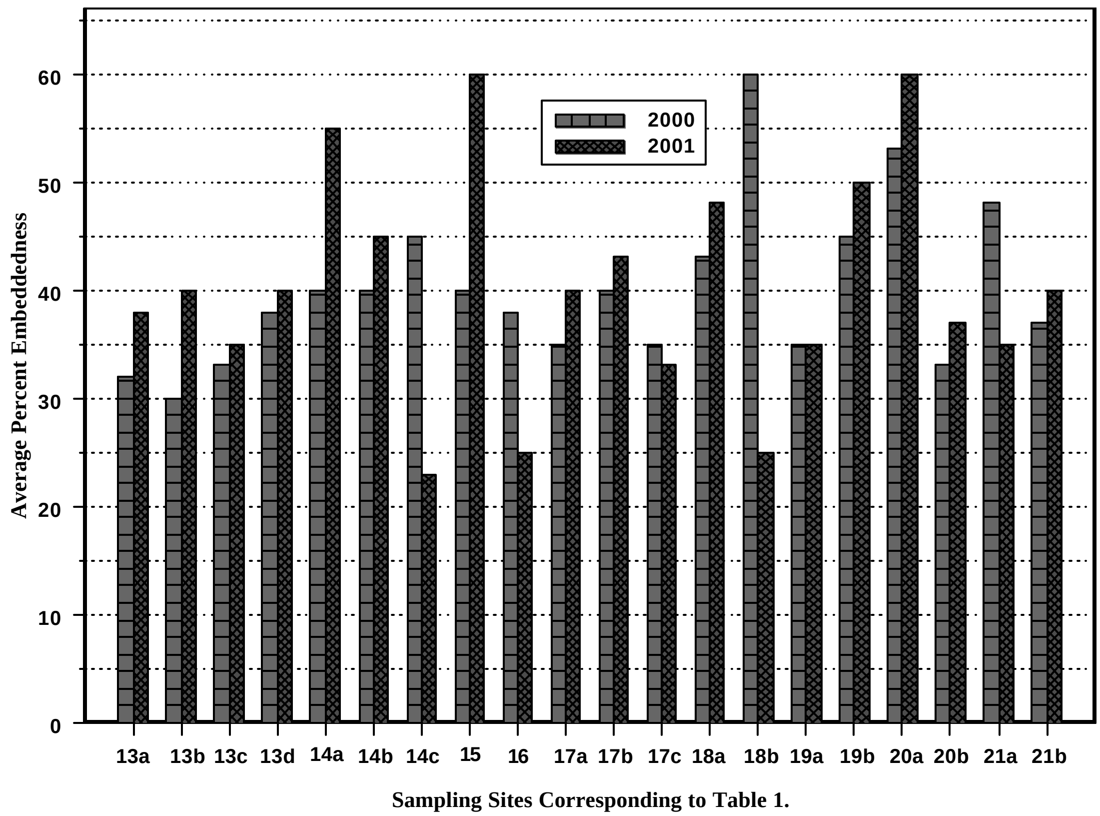


Figure 30b. Average Percent Embeddedness in Pool Habitat at Tributary Sites in 2000 and 2001.

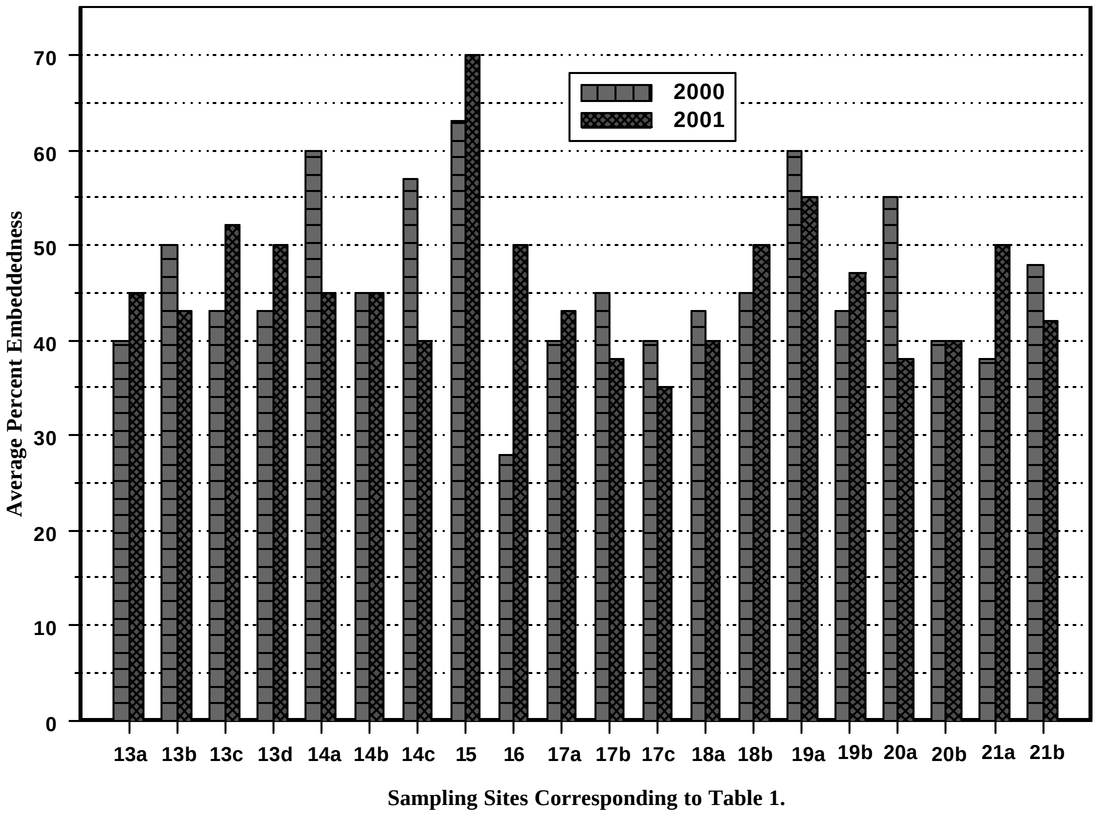


Figure 31. Average Escape Cover Indices for Pools at Tributary Sampling Sites in 2000 and 2001.

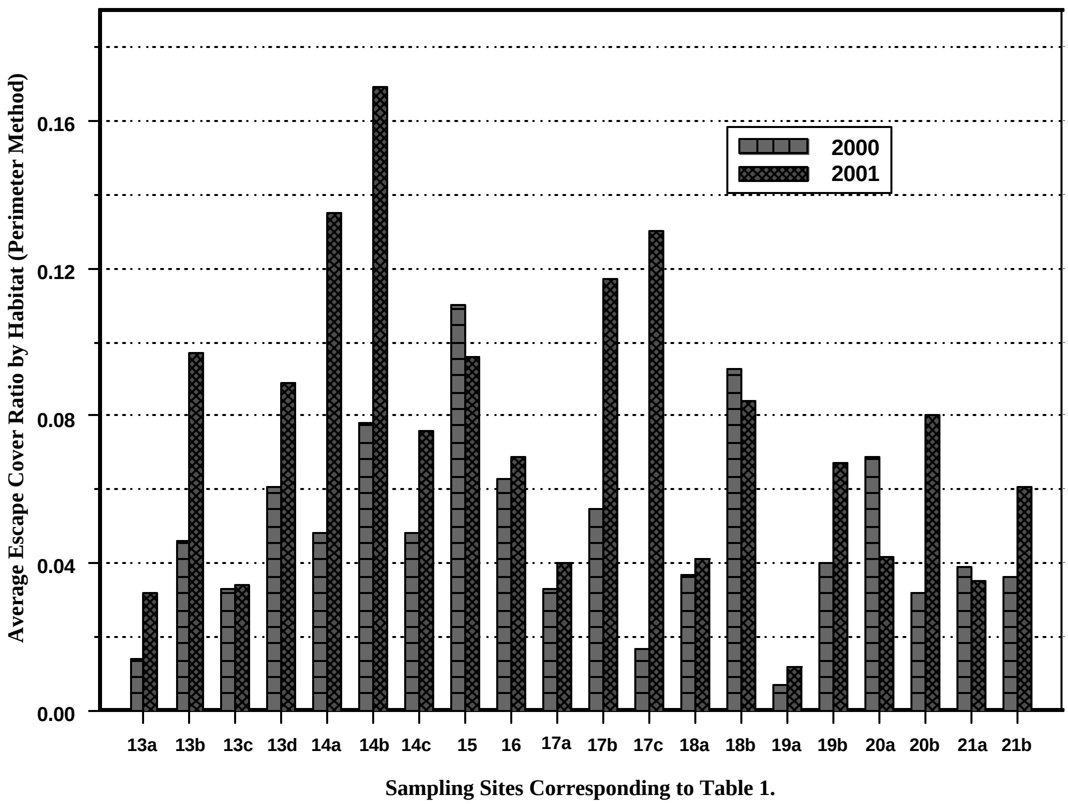


Figure 32. Averaged Mean Depth in Pools at Tributary Sampling Sites in 2000 and 2001.

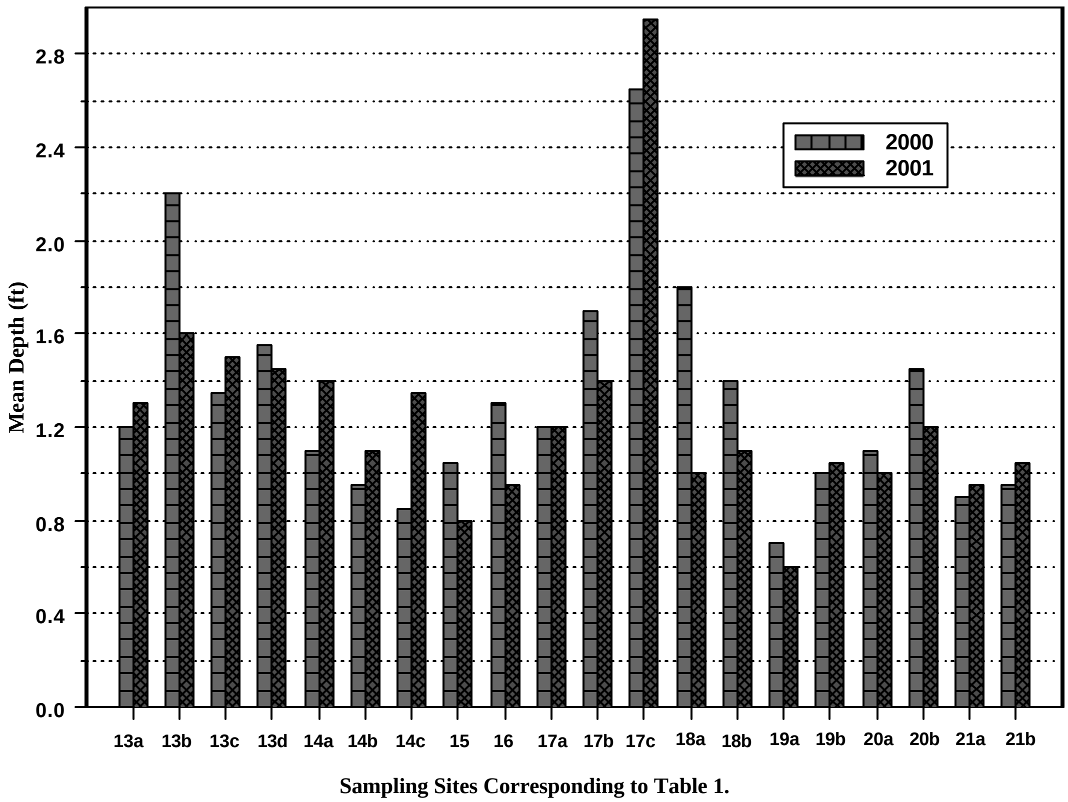


Figure 33. Averaged Maximum Depth in Pools at Tributary Sampling Sites in 2000 and 2001.

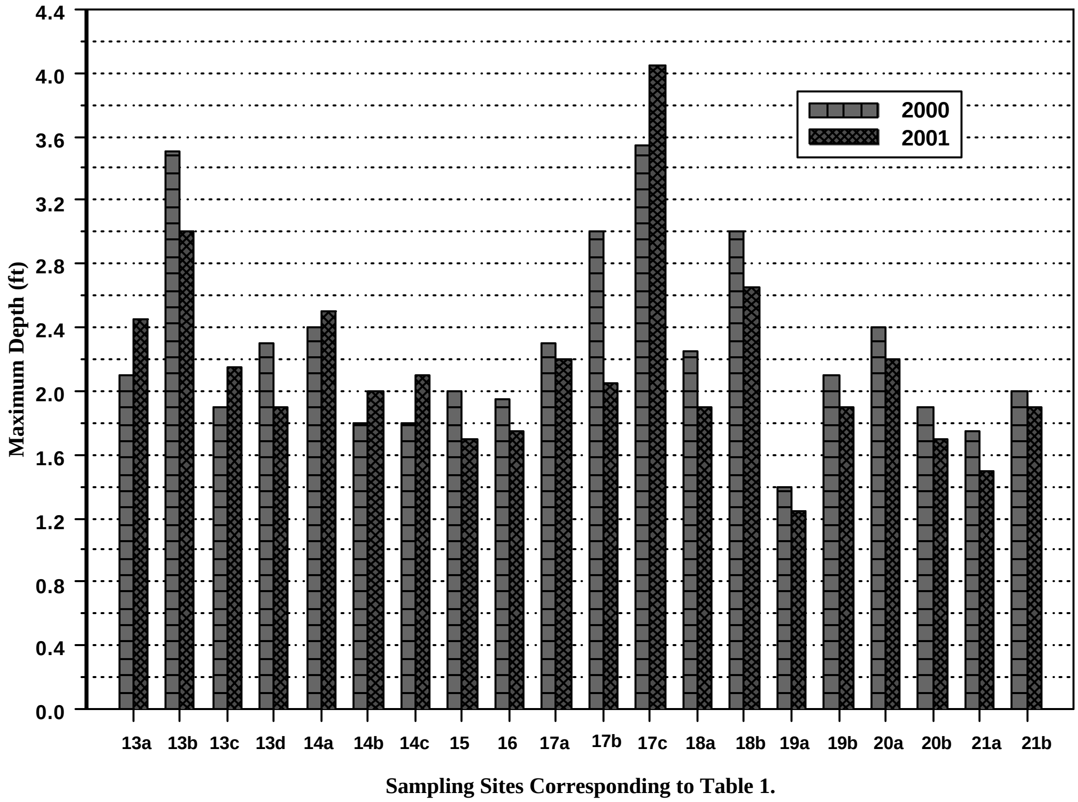
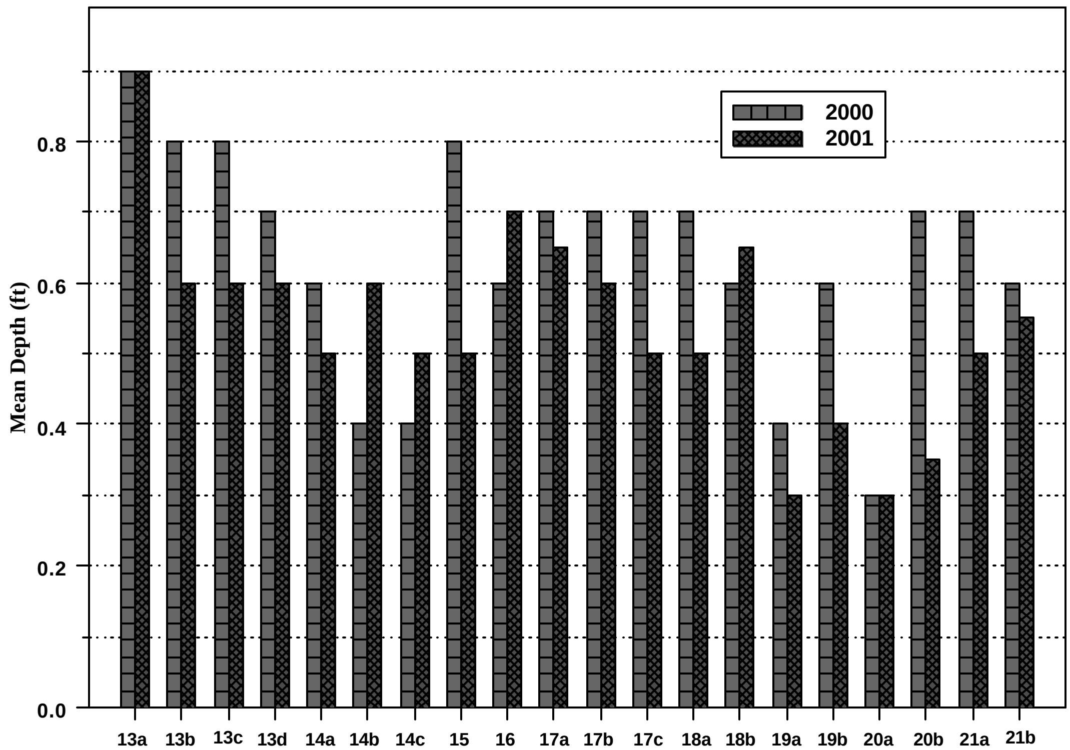


Figure 34. Averaged Mean Depth in Runs/Step-runs at Tributary Sampling Sites in 2000 and 2001.



Sampling Sites Corresponding to Table 1.

Figure 35. Streamflow Measured by Flowmeter at Sampling Sites on the Mainstem San Lorenzo River and Lower Zayante Creek in 1995-96 and 1998-2001.

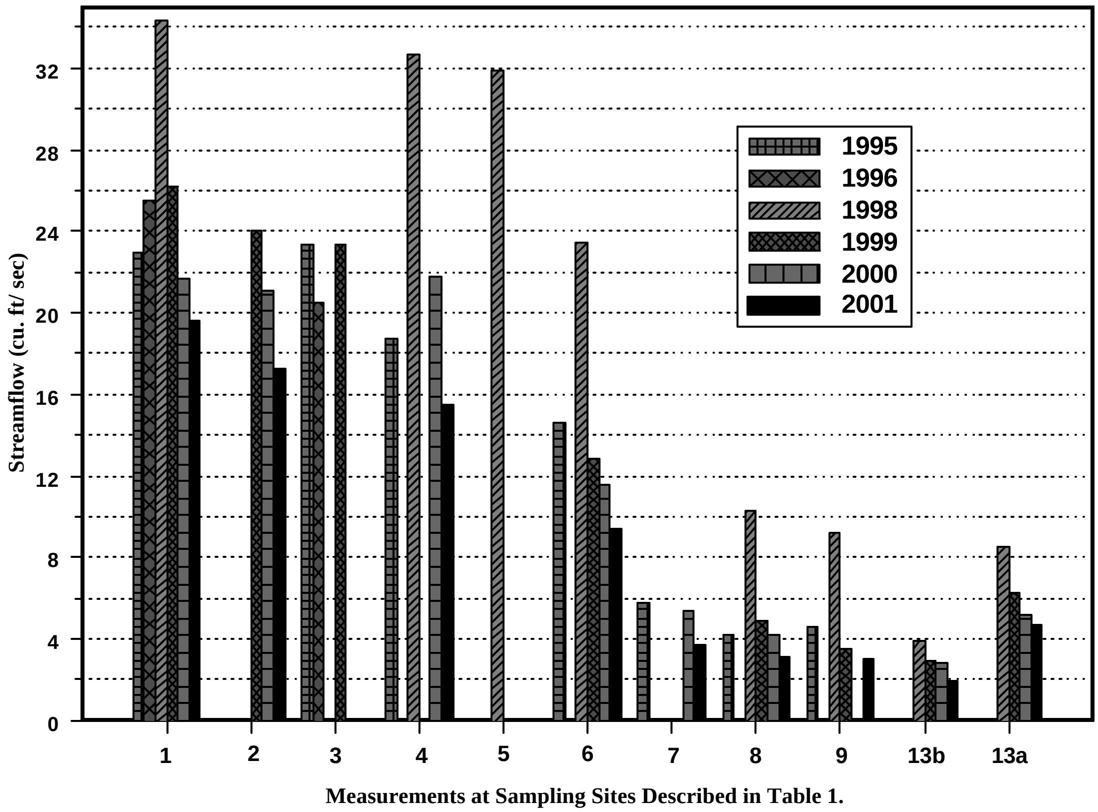


Figure 36. Streamflow Measured by Flowmeter at Sampling Sites in Tributaries to the San Lorenzo River in 1995-96 and 1998-2001.

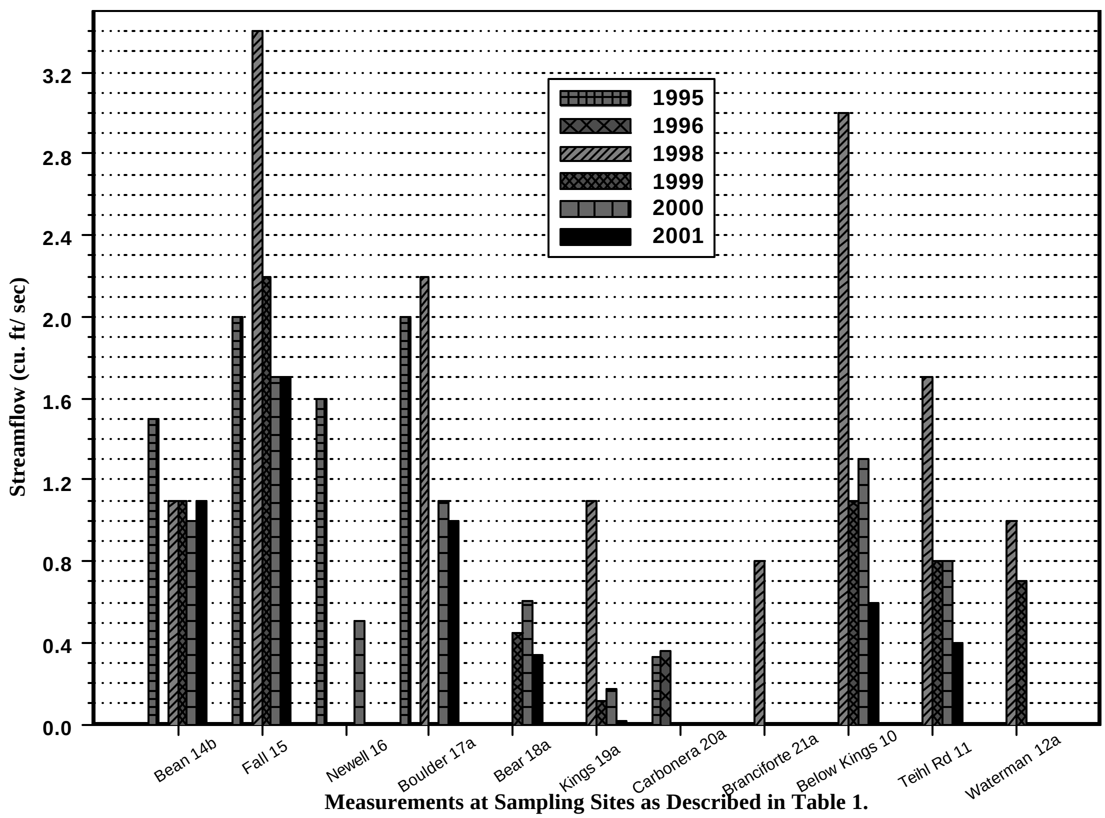


Figure 41 The 2000 daily average discharge and peak flood flows above 1800 cfs for the USGS gage on the San Lorenzo River at Big Trees.

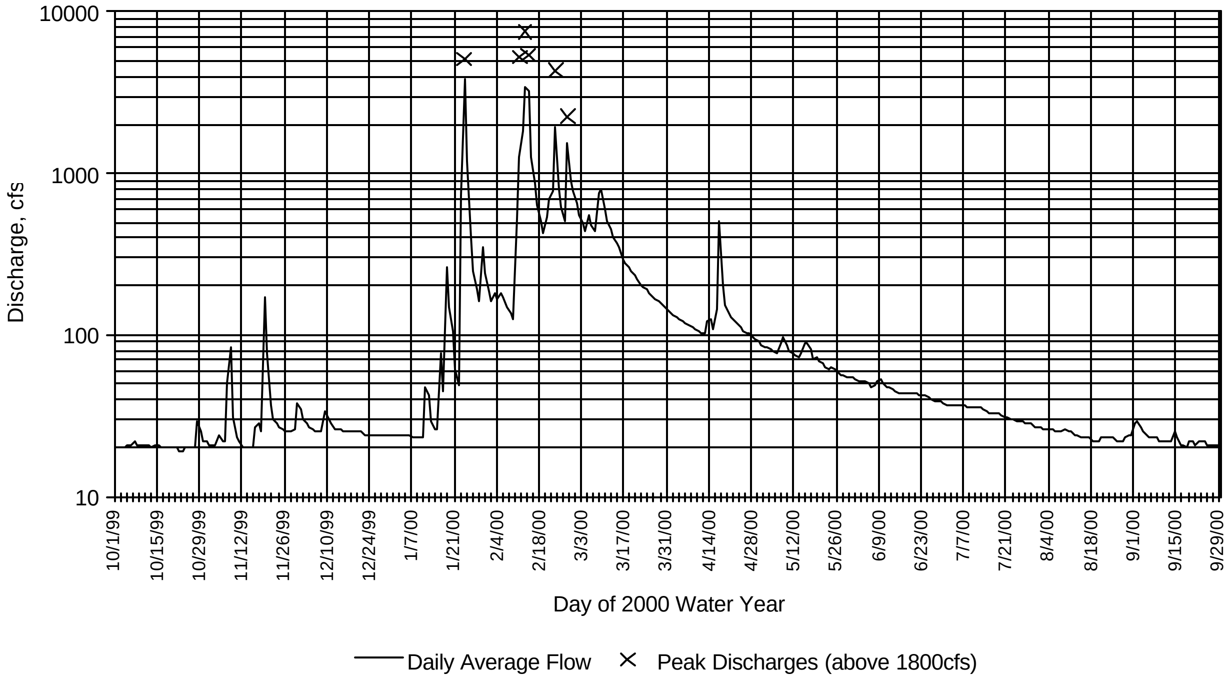
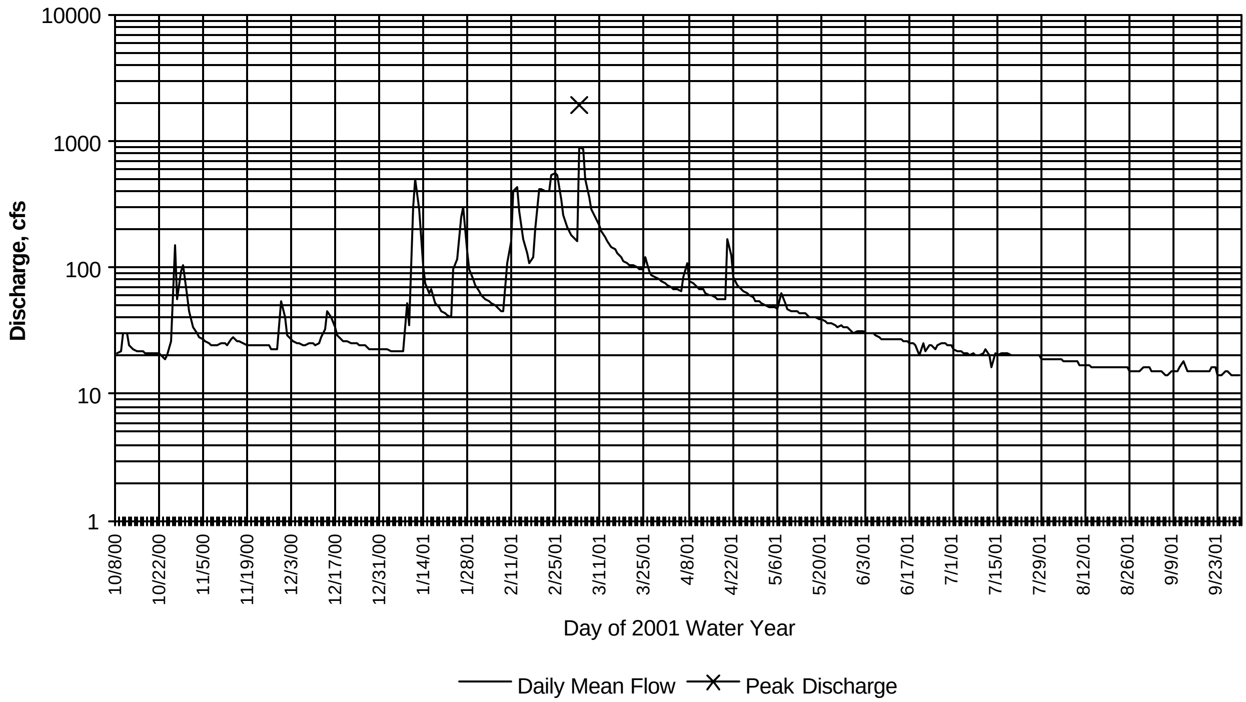
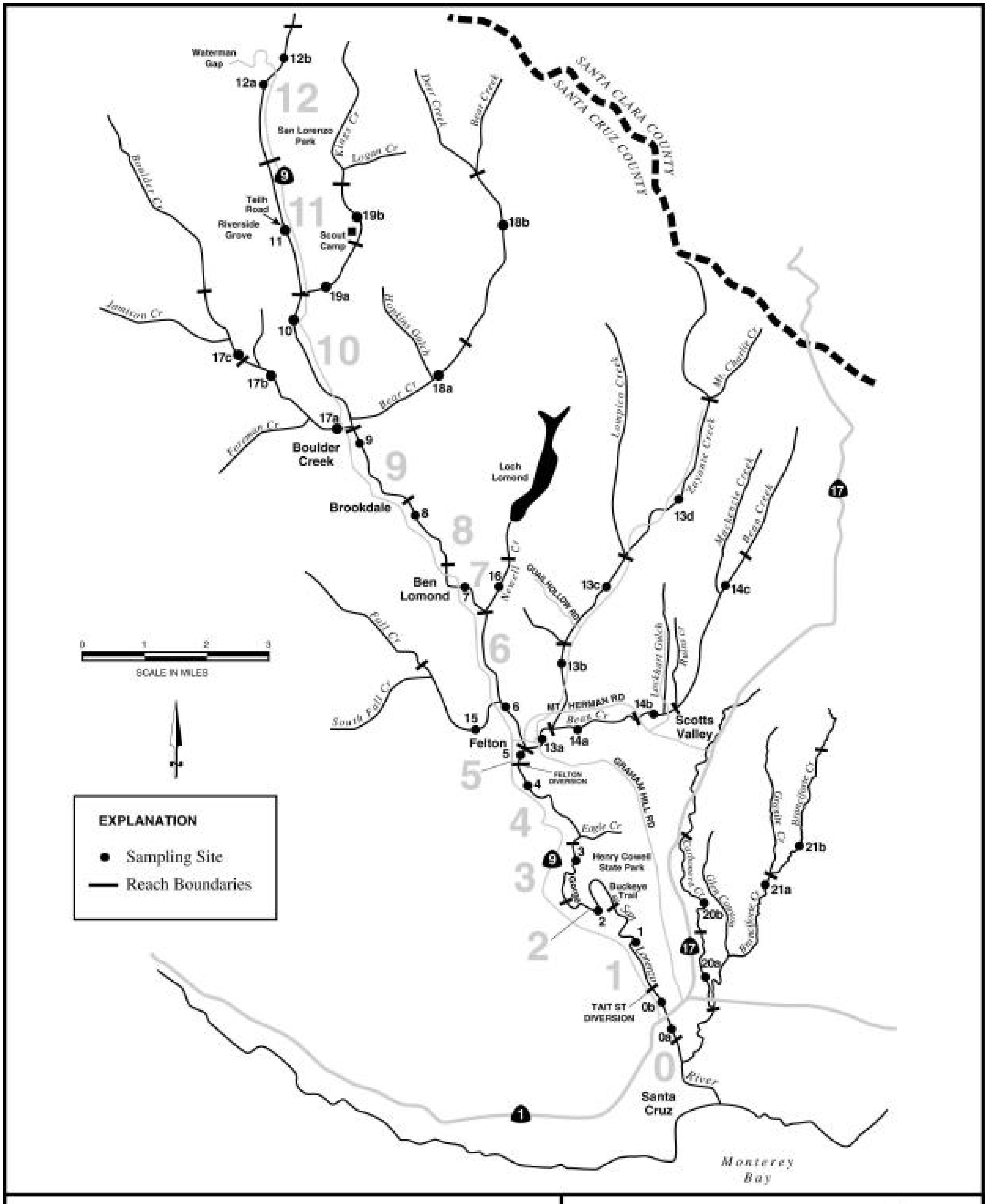


Figure 42 . The 2001 daily mean and peak flood flow for the USGS gage on San Lorenzo River at Big Trees. (Preliminary, subject to change)



APPENDIX A. Maps of the San Lorenzo River Drainage.



APPENDIX A, FIGURE 2 Reach & Site Designations in the San Lorenzo River Drainage

June 2001

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APPENDIX B. Summary of Catch Data for Sampling Sites.

ORDER OF DATA ORGANIZATION IN THIS APPENDIX

The summary sheets for each sampling site were provided first as steelhead/coho sampling forms. Then the field data sheets for each sampling site were provided. The order of sampling sites corresponded to the numerical order presented in Table 1c of the text on pages 51-52 of the methods section.

EXPLANATION OF STEELHEAD/COHO SALMON SAMPLING FORMS

Electrofishing and snorkeling data were presented for each sampling site. All data pertained to steelhead because no coho salmon were captured in 2000. Snorkeled habitat is denoted. For electrofishing data, it was presented in successive passes. For underwater visual censusing data, fish counts for replicate passes were presented as passes. Density estimates for each electrofished habitat were obtained by the depletion method and regression analysis. Density estimates for mainstem pool habitats that were visually censused in 2000 were obtained by using the maximum number of steelhead seen per pass. Densities were so low in 2000 that there was little chance of counting the same fish twice, and it was very possible to miss fish on certain passes.

For each pass, steelhead were divided into age and size class categories. Y-O-Y and 1+ refer to age classes. C-1, C-2 and C-3 refer to Size Classes 1, 2 and 3. For the data presented by pass, C-2 includes Size Classes 2 and 3 combined. Only in the population estimates are these two size classes differentiated.

Site densities at the bottom of the summary data forms were obtained by dividing total estimated number of fish in each size/age category by the total length of stream that was censused.

APPENDIX C. Habitat Data and Fish Sampling Data at Sampling Sites.